MINISTRY OF TRANSPORT &
COMMUNICATIONS
SULTANATE OF OMAN

JAPAN INTERNATIONAL
COOPERATION AGENCY

THE STUDY ON ROAD NETWORK DEVELOPMENT IN THE SULTANATE OF OMAN

FINAL REPORT
MAIN REPORT-2
PRE-FEASIBILITY STUDY

MARCH 2005

KATAHIRA & ENGINEERS INTERNATIONAL

Exchange Rate:

US$1.00 = RO 0.385

RO 1.00 = JPY 278

(As of November 2004)

PREFACE

In response to a request from the Sultanate State of Oman, the Government of Japan decided to conduct the Study on Road Network Development and entrusted the project to Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Dr. Hani Abdel-Halim at Katahira & Engineers International from January 2004 to February 2005.

The team held discussions with the engineers at Directorate General of Roads, Ministry of Transport and Communications, as well as other officials concerned, and conducted field surveys, data analysis, Master Plan formulation and Feasibility Study. Upon returning to Japan, the team prepared this final report to summarize the result of the study.

I hope that this report will contribute to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Sultanate State of Oman for their close cooperation extended to the study.

March 2005

Kazuhisa MATSUOKA,
Vice President
Japan International Cooperation Agency

Mr. Kazuhisa MATSUOKA
Vice President
Japan International Cooperation Agency

March 2005

Letter of Transmittal

Dear Sir,

We are pleased to submit herewith the Final Report of "The Study on Road Network Development in the Sultanate of Oman". The report includes the advices and suggestions of the authorities concerned of the Government of Japan and your agency as well as the comments made by the Ministry of Transport & Communications and other authorities concerned in the Sultanate of Oman.

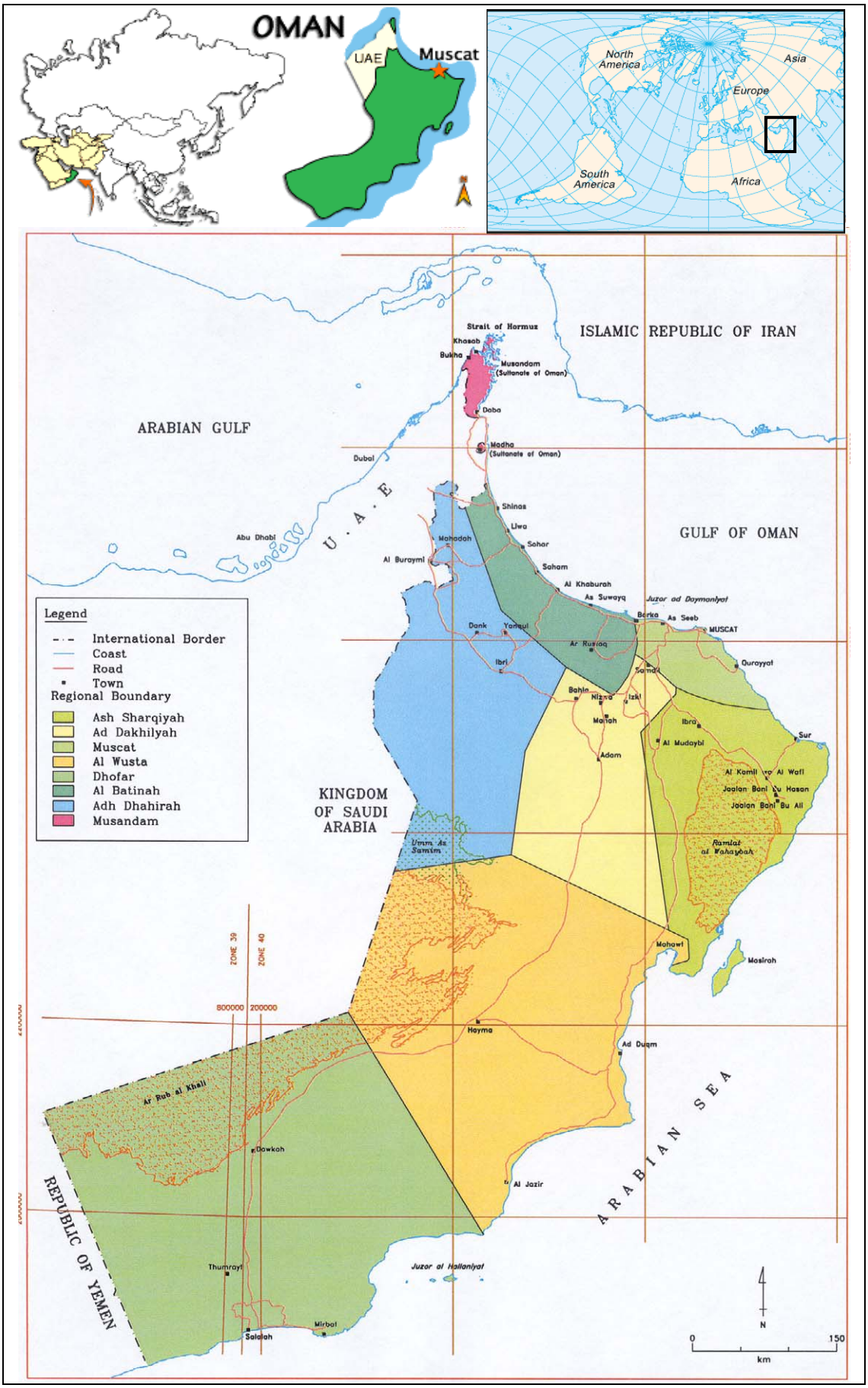
The report analyses the present and future conditions and demand of transport in the Sultanate. It comprehensively covers the road transport sector as well as the issues of institution, financing and environment.

The report presents the established road network development plan to the year 2030, and pre-feasibility study on high priority projects. The output of the Study concludes that the plan is technically, environmentally, economically and socially viable, and will contribute to the national and regional development in the Sultanate. In view of the urgency of developing the road network in the Sultanate, we recommend that the Government of the Sultanate of Oman implement the projects with high priority.

We wish to take this opportunity to express our sincere gratitude to your agency, the Ministry of Foreign Affairs and the Ministry of Land, Infrastructure and Transport. We also wish to express our deep gratitude to the Ministry of Transport & Communications, Directorate General of Roads as well as other Governmental Agencies concerned in the Sultanate of Oman for the close cooperation and kind assistance extended to us during the Study. We hope this report will contribute significantly to the development of the Sultanate of Oman.

Very truly yours,

Dr. Hani Abdel-Halim
Team Leader,
The Study on Road Network Development
in the Sultanate of Oman



Location Map

Report Composition

The Final Report of the Study is structured to meet the requirements of two user-groups, either for experts in-charge of planning or technical feasibility studies. It contains the following five volumes:

EXECUTIVE SUMMARY: is designed to address the decision-makers who do not extensive information in technical and engineering aspects. It contains brief information on all the major aspects of the Study, and concentrates on input and output of each aspect. It contains also a more concentrated summary for the main conclusions.

MAIN REPORT – 1 "Road Network Development Plan": is designed for planners, engineers and directors of DGR and concerned ministries and authorities, who need more technical information on the Master Plan formulation. It contained comprehensive information on the present conditions in sectors related to the Study, planning objectives and strategies, development and evaluation of alternatives, components of planned projects, prioritization in the planning process, evaluation results of the Master Plan and overall implementation plan. This report contains the Chapters from 1 to 16.

MAIN REPORT – 2 "Pre-Feasibility Study": is designed to include technical and detailed studies carried out on significant projects selected in line with the policies and concept of the Master Plan. The report gives the objectives, preliminary design, cost estimate and project evaluation on the technical, environmental and economic viability of four road projects. In addition, it contains other detailed studies conducted on three projects on specific fields of environment, hydrology and management. This report contains the Chapters from 17 to 26.

APPENDIX: to contain necessary data, calculations and other information produced during the course of the Study.

DRAWINGS: to contain preliminary design drawings produced for the Pre-Feasibility Study projects.

MAIN REPORT – 2: PRE-FEASIBILITY STUDY

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ABBREVIATIONS

4WD	:	Four Wheel Drive
5YDP	:	Five-Year Development Plan
AADT	:	Annual Average Daily Traffic
AAGR	:	Annual Average Growth Rate
AASHTO	:	American Association of State Highway and Transport Officials
AC	:	Asphalt Concrete
ADT	:	Average Daily Traffic
amsl	:	above mean sea level
AP	:	Aden Port
ASFR	:	Age-Specific Fertility Rate
BAR		Bowshar – Al Armarat Road
B/C	:	Benefit/Cost Ratio
BC	:	Box Culvert
BOOT	:	Build, Operate, Own and Transfer
BOT	:	Build, Operate and Transfer
bpd	:	Barrel per Day
BS	:	British Standard
CC	:	Cement Concrete
DBST	:	Double-Layer Bituminous Surface Treatment
DD	:	Detail Design
DGC	:	Directorate General of Communications (in Dhofar)
DG	:	Director General
DGR	:	Directorate General of Roads
DGWRA	:	Directorate General of Water Resources Assessment
DNC	:	Do Nothing Case
DOT	:	UK Department of Transport
DST	:	Double Surface Treatment
EBH	:	Existing Batinah Highway
EIA	:	Environmental Impact Assessment
ESCWA	:	Economic and Social Committee for Western Asia
EIRR	:	Economic Internal Rate of Return
FFCO	:	Flood Frequency Curve of Oman
F/S	:	Feasibility Study
FIRR	:	Financial Internal Rate of Return
FPF	:	Flood Peak Frequency
FTZ	:	Free Trade Zone
FYDP	:	Five-Year Development Plan
GCCS	:	Gulf Co-operation Council Standard
GDP	:	Gross Domestic Products
GR	:	Grouted Riprap
GRDP	:	Gross Regional Domestic Products
GVA	:	Gross Value Added
ha	:	hectare
HCM	:	Highway Capacity Manual
HDM	:	Highway Design Manual

HUC	:	Highway User Cost
IB	:	Irish Bridge
ICC	:	Industrial Clarification Code
IEE	:	Initial Environmental Examination
IMF	:	International Monetary Fund
IR	:	Internal Regulation
ISIC	:	International Standard Industrial Classification
JICA	:	Japan International Cooperation Agency
LFPR	:	Labor Force Participation Rate
LNG	:	Liquefied Natural Gas
LOS	:	Level of Service
MAF	:	Mean Annual Flood
M/P	:	Master Plan
MCI	:	Ministry of Commerce and Industry
Mcm	:	Million cubic meters
MD	:	Ministerial Decision
MOAF	:	Ministry of Agriculture and Fisheries
MOC	:	Ministry of Communications
MOCI	:	Ministry of Commerce and Industry
MOD	:	Ministry of Defense
MOE&W	:	Ministry of Electricity and Water
MOF	:	Ministry of Finance
MOG	:	Ministry of Oil and Gas
MOH	:	Ministry of Health
MOHC	:	Ministry of Heritage and Culture
MONE	:	Ministry of National Economy
MOT&C	:	Ministry of Transport and Communications
MRMEWR	:	Ministry of Regional Municipalities, Environment and Water Resources
MWR	:	Ministry of Water Resources
N.A., N/A	:	Not Available
NBE	:	New Batinah Expressway
NPV	:	Net Present Value
NR	:	National Road
NSA	:	National Survey Authority
OD	:	Origin-Destination
PC	:	Precast Concrete
PC	:	Pipe Culvert
P/C table	:	Production and Consumption Table
PCE	:	Passenger Car Equivalent
PCSG	:	Pre-stress Concrete Steel Girder
PCU	:	Passenger Car Unit
PDO	:	Petroleum Development of Oman
PFI	:	Private Finance Initiative
POT	:	Peak Over Threshold
PSS	:	Passing Sight Distance
R/A	:	Roundabout
RC	:	Reinforced Concrete

RCSG	:	Reinforced Concrete Steel Girder
RD	:	Royal Decree
RD/DGC	:	Road Department of DGC
RDI	:	Road Density Index
RO	:	Riyal Omani
ROP	:	Royal Oman Police
ROW	:	Right of Way
SCTP	:	Supreme Committee for Town Planning
SGRF	:	State General Reserve Fund
SPT	:	Standard Penetration Test
QSR	:	Quriyat - Sur Road
SSD	:	Stopping Sight Distance
ST	:	Surface Treatment
TEU	:	Twenty Feet Equivalent Unit
TFR	:	Total Fertility Rate
TOR	:	Terms of Reference
TRB	:	Transportation Research Board (USA)
TRL	:	Transport Research Laboratory
TTC	:	Travel Time Cost
UAE	:	United Arab Emirates
UK	:	United Kingdom
VCR	:	Volume/Capacity Ratio
veh	:	Vehicle
VOC	:	Vehicle Operating Cost
vpd	:	Vehicle per day
ph	:	Vehicle per hour

PART III

PRE-FEASIBILITY STUDY

CHAPTER 17

SELECTED PROJECTS FOR PRE-FEASIBILITY STUDY

CHAPTER 17

SELECTED PROJECTS FOR PRE-F/S STUDY

17.1 SELECTION PROCEDURE

This Study on the Road Network Development in the Sultanate of Oman is composed of two main phases. The first phase is to formulate the development plan for primary and secondary road networks to the target year of 2030. The main task of the second phase is to carry out preliminary feasibility studies (Pre-F/S) on selected projects with high priority for implementation, basically from the coming 7th Plan. The 7th Plan includes 19 road projects, either as dualization or new construction, with a total length of more than 1,000 kilometers.

In general, the main links or skeleton of the road network in Oman is well developed and connects regions, wilayats and major development centers as well as major transport facilities as airports and ports. In addition, it can meet the present transport demand requirements and basic functions of a road network in a satisfactory level. In the short-term development of the road network, the Master Plan generally shows that small-scale projects for improvements are required to improve the overall functions of the road network, while major and large-scale projects are required in the medium and long terms due to the considerable increase in the transport demand in future.

In the selection of the high priority projects for the Pre-F/S, basically significant road projects in line with the policy and concept of the Nationwide Master Plan are selected, providing that such projects require Pre-F/S before future implementation. In the mean time the following criteria are considered:

Urgency: Projects that are in urgent need for implementation, and intended to solve urgent transport problems and greatly improve the network function.
Integration: Projects that promote and provide integration with other socioeconomic development projects.
Regional Balance: Projects that are distributed in different regions to promote regional development and knowledge for regional offices.
Technical Issues: Projects that require technical depth in important issues such as environmental assessment, hydrological analysis at Wadi locations and privatization schemes through the systems of built-operate-transfer (BOT) and public-private-participation (PPP).

17.2 STATUS OF 7TH 5-YEAR PLAN PROJECTS

The projects included under the 7th Plan are the most urgent and required projects that will provide quick impact on the efficiency of the road network and meet the objectives and policy of the Master Plan. The status of all projects included in the 7th 5-Year Plan is investigated through information from both DGR and DGC. As the 7th Plan will start by the year 2006 with only short period before implementation activities, most of its planned projects are already in the design or tendering stages after carrying out required feasibility studies as shown in Table 17.2-1.

Table 17.2-1 Status of 7th Plan Projects

Project No.	Project	Region	Length Km	Project Status
D3-1	Nizwa - Bahla	A'Dakhliyah	40	FS+PD June 04 - UD
D3-2	Bahla - Ibri	Adh Dhahira	85	FS+PD June 04 - UD
D5-1	Majis (Sohar) - Az Zarub	Batina/A'Dhahi	81	FS April 04 - TD
D7	Ma'mura - Taqah	Dhofar	20	TD 1993
D8	Muladdah - Hazm	Batinah	24	TD 1998
D-9	Quriyat - Sur Phase III	Ash Sharqiya	18	TD 2004
N4	Diba - Khasab	Musandam	95	FS June 04 - UD
N5	Lima Link - Khasab	Musandam	25	FS - UD
N6	Al Ashkharah - Shanna	Ash Sharqiya	164	FS March 04 – UD
N9	Marmul - Sawqrah	Dhofar	140	FS March 04
N10	Shelim-Shuaymiyah	Dhofar	48	FS April 04 + TD
N12	Madinat AL Haq-Nashib	Dhofar	28	PD May 04 - UD
N14	Teetam-Qaftat	Dhofar	12	PD June 04 - UD
N26	Thumrait - Marmul	Dhofar	86	FS + TD
N27	Hamra-Rustaq, PhaseIV	Bat/Ad Dhakh.	28	-
N28	Yanqul-Fida-Dank	Adh Dhahira	41	TD
N30	Madha - Dafta	Musandam	15	-
N36	Mahlah - Ismaiyah	Ash Sharqiya	38	-
N47	Al Hij - Flim	Al Wusta	19	-

Notes:
FS: Feasibility Study (by consultant; economic analysis based on rough design)
PD: Preliminary Design
DD: Detailed Design
TD: Tender Documents (by consultant)
UD: Under Design (by consultant for complicated projects or by contractor for simple projects; to include P/D, D/D and TD)

17.3 SELECTED PROJECTS

Due to the limited number of projects selected from the 7th Plan that meet the criteria and require Pre-F/S, and that some of the projects in the 8th Plan are important, but delayed due to financial constraints, it was agreed with DGR to include some of these projects in the Pre-F/S stage. The selected projects from the 8th Plan are considered as complicated projects that have technical importance and require special considerations and specific viability before implementation.

The selected road projects for Pre-F/S, that are in line with the policy and concept of the Nationwide Master Plan and confirm with the established criteria are as presented in Table 17.3-1. Figure 17.3-1 shows a location map for the selected projects.

Table 17.3-1 Pre-F/S Projects

Major Task	Road	Project No.	Length (km)	Region	Plan	Justification
Technical Study	Hamra – Rustaq	N27	28	Bat/A'Dakh	7th	To improve network efficiency and high transport demand
	Madha – Dafta	N30	15	Musandam	7th	To strengthen integration and social welfare
	Al Hij – Flim	N47	19	Al Wusta	7th	To promote regional and tourism development
	Mahlah – Ismaiyah		38	A'Sharqiya	7th	To improve network efficiency in populated mountainous areas
Environ-mental Study	Hasik – Shuwaymiyah		120	Dhofar	8th	To assess the road impact as it passes through environmentally protected areas in both mountain and sea sides
Wadi Study	Batinah Highway	U1	270	Batinah	8th	To carry out hydrological analysis at wadis to replace Irish crossings to culverts and to provide underpasses at at-grade junctions
Manage-ment Study	New Batinah Expressway	N1	246	Batinah	8th	To study financing and management systems for private sector participation

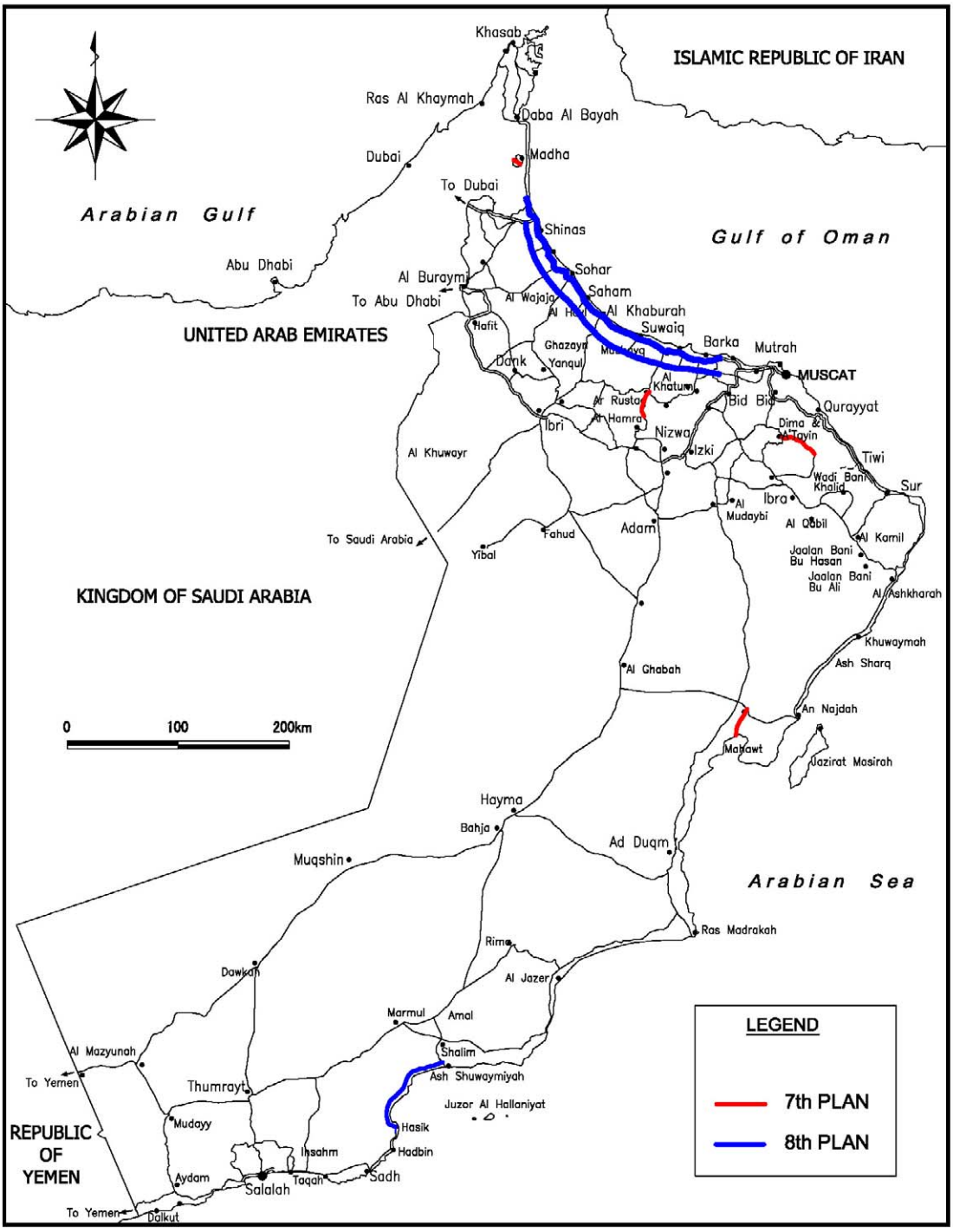


Figure 17.3-1 Location Map of Pre-F/S Projects

The four projects selected from the 7th Plan, as listed above, will be subject to all Pre-Feasibility Study tasks. As for the three projects selected from the 8th Plan, the study will concentrate only on the major task for each project.

The following sections provide an explanation on the nature of each of the selected projects.

1) Hamra – Rustaq Road Project (Phase 4): A 2-lane paved road connecting Ar Rustaq in Batinah Region and Al Hamra in Ad Dakhliyah Region is currently being constructed across Al Hajar Al Ghabri Mountain Range. This road project is divided into 4 phases. Phase 1 (L = 15.0 km) is already completed. Phase 2 (L = 13.7 km) is under construction. Phase 3 (L = 9.5 km) is being designed. Phase 4 is the final section of this road and connects this road with NR No. 13. Upon completion, Al Hamra-Rustaq Road is expected to contribute to strengthen the communication between Barka/Rustaq area and Al Hamra/Bahla/Nizwa area. It is also expected to function as a detour route for NR 15 (Rusayl-Nizwa Road).

2) Madha – Dafta Road Project: Madha is the central town of Oman territory in UAE territory, isolated from the main Oman territory of Musandam. (See Chapter 19.) There is a road connecting Qidfa in UAE (in the east of Madha) and Dafta in UAE (in the west of Madha), traversing the territory of Oman in east-west direction. This road passes an isolated UAE territory existing in Oman territory around Madha. The local residents desire to go to Dafta without passing the isolated UAE territory in Madha area. Therefore, they requested DGR to alter the route of the existing road so that they can go to Dafta without passing the isolated UAE territory.

3) Al Hij – Flim Road Project: Flim is small fishing village. There is a small island called Mahawt Island about 5 km offshore from Flim. This island is currently used as the base for fishing. The sea between Mahawt Island and Flim is very shallow and the bottom of the sea is visible during ebb tide. Substantial part of the island and shore is covered by mangrove. The sea water is clear. There is plan to develop this area as a tourist spot. The Project is to support the tourism development, as well as to improve the access of the local residents to the market (to sell fish).

4) Mahlah – Ismaiyah Road Project: The central valley of Al Hajar Ash Sharqi Mountain Range has rich underground and surface water. Accordingly, this area has high potential of agriculture and tourism. The Project Road longitudinally traverses the central valley. The section of NR 25 from Sabikah on NR 23 to Mahlah is already paved. Therefore, Mahlah – Ismaiyah Road is an extension of

this NR 25. Also, Project N33 (Tiwi-Ismaiyah) and N38 (Al Mazari-Ghubrat At Tam) are to be connected to Mahlah – Ismaiyah Road and N37 (Qaran-Maqal-Sayq-Sabt-NR 23) Road. Accordingly, this road, together with N37 Road, is expected to function as the axis of the local network. They are also expected to function as the local detour route for NR 23(Bid Bid - Sur Road).

5) Hasik – Shuwaymiyah Road: This proposed road is the missing link in the coastal road south of the country in Dhofar. While this road is expected to enhance the function of road network in the area and contribute to socioeconomic acitivities of the area, the area is environmentally critical that require great care in identifying its alignment and design. The road is considered as an important link in the road network; however, implementation of the road will be based on the results of its EIA.

6) Upgrading of Batinah Highway: This project is to provide culverts at Irish-crossing sections along this most important highway in the country in order to upgrade it as an all-weather highway. In addition, the viability of providing grade-separation structures at at-grade junctions and intersections in order to provide safety facilities at such black-spots is investigated.

7) New Batinah Expressway: This project is to construct a divided, 4-lane, full access-controlled expressway. The Project Road is to run parallel to the existing Batinah Highway. The location of the route is currently being studied by the Supreme Committee for Town Planning (SCTP). According to SCTP, the most probable location of the route is approximately 10 km from the existing Batinah Highway to south (to the mountain). At the Muscat-side end (near Filaiji R/A or Halban R/A), this expressway is to be connected to the Southern Expressway which traverses As Seeb and reach Al Qurm. Construction of the Southern Expressway is expected to be started in near future. (Tender documents have been prepared.) The Government intends to introduce “private participation” for financing the cost of the New Batinah Expressway. But private participation in the area of road is still new to Oman. Therefore, possibilities of private participation under a few scenarios are examined.

17.4 STUDY PROCEDURE

For the four projects categorized as “Technical Study” in Table 17.3-1, (Hamra – Rustaq, Madha – Dafta, Al Hij – Flim, and Mahlah – Ismaiyah), studies are conducted in the following procedures.

1) Identification of study section: This is done on 1:100,000 topographical map.

General alignment and starting and end point are confirmed. Discussion is held between DGR and the Study Team as Necessary.

2) Field survey: The Study Team members and DGR officials (mainly the Counterparts), and relevant consultant or contractor, visit the site of the project and confirm the possible alignment, start point and end point of the study road. Then, the Study Team members conduct simplified survey on the topography along the proposed alignment. Locations of necessary drainage facilities are marked and recorded. The GPS data of the proposed alignment is recorded to be used in presenting the proposed alignment on 1:100,000 topographical map.
3) Preliminary design: The Study Team member draws cross sections and estimate quantity of earth works. Quantities of other items such as slope protection, drainage, pavement, etc are estimated. The drawings of alignment, cross sections, drainage facilities, etc. are complied in a separate volume ("Drawings").
4) Cost estimate: Based on the quantities estimated in the above, construction cost is estimated.
5) Economic evaluation: Using the construction cost as described above and estimated economic benefits calculated from the estimated traffic volume, three economic indicators (Net Present Value (NPV), Benefit/Cost Ratio (BCR) and Internal Rate of Return (IRR)) are calculated.

For the "Environmental Study" of Hasik-Shuwaymiyah Road, almost same procedure was followed except economic evaluation. In case of this road, the main focus was consideration on environmental impact. Therefore, economic evaluation was not carried out.

For the "Wadi Study" of Batinah Highway which involves construction box culverts, types of culverts are selected based on the survey on the conditions of Irish crossings. The costs are estimated based on the design of culverts. Economic evaluation is made by comparing the cost and economic benefit accruing from the elimination of disturbance to the traffic.

For the "Management Study" of New Batinah Expressway, some variations of toll rate system and resulting toll revenues are estimated and examined. Possible tolling system is proposed.

CHAPTER 18

HAMRA - RUSTAQ ROAD

CHAPTER 18

AL HAMRA - RUSTAQ ROAD (PHASE 4)

18.1 OBJECTIVE OF THE PROJECT

The existing Al Hamra - Rustaq road (Project No. N27, Batinah Region) which connects between National Road (NR) 13 in Rustaq side and NR 21 in Al Hamra side is unpaved stony and rough road. The road is passable only by four (4) wheel drive (4WD) vehicle. In Master Plan Study, this road becomes important road link between NR 13 and NR 21 across Al Hajar Al Ghabri Mountain Range connecting A'Dakhliyah Region with the coastal area.

Taking into account the importance of this road, the Government intends to improve this Al Hamra - Rustaq road. The improvement project of this road divided into four (4) stages as described below:

- Phase 1: Length 15.000 kilometers
- Phase 2: Length 13.660 kilometers
- Phase 3: Length 9.500 kilometers
- Phase 4: Length 28.300 kilometers

Location map is shown in Figure 18.1-1.

Figure 18.1-1 Location of Project Site

The construction of Phase 1 project was already completed in January 2003 and opened to traffic, and the construction of Phase 2 project is now on-going and is expected to be completed in 2005. Phase 3 project has already been tendered-out and designing is now being conducted by the contractor. However, due to some difficulties of the severe terrain conditions, preliminary design of Phase 3 is haltered at present, and design of Phase 4 has not been started yet. Therefore, DGR requested the Study Team to carry out the pre-feasibility study of this project. The objectives of the project are:

a) To complete road linkage between NR 13 and NR 21 across Al Hajar Al Ghabri Mountain Range,
b) To provide proper access road for people who are living along the project road, and
c) To provide a diversion road of NR 15 between Muscat and Nizwa if necessary.

18.2 ALIGNMENT AND PRELIMINARY DESIGN

18.2.1 Physical Features of Project Site

The topography of the area where Al Hamra - Rustaq road traverses is roughly divided into northern side and southern side according to its topographic features.

The southern side is comparatively moderate rolling terrain, but climbs up approximately 1,400 meters of the elevation before reaching the peak of the mountain. The northern side has the cliff at the top of the mountain and climbs down approximately 1,000 meters of the elevation to the foot of the cliff, where the village of Hatt is located in Wadi al Hat. From Hatt to the Rustaq side, the road is passing through mountainous terrain and sometimes is required to pass the small ridges where the road alignment transfer from one wadi to the other. Therefore, the road traverses almost inside the wadis, and gets down the altitude moderately to 400 meters above sea level.

18.2.2 Existing Road Condition

The road stretch is divided into four sections by the construction phases. Phase 1 & 2 are located in the southern side while Phase 3 & 4 are in the northern side. This Study focuses only on Section 4 between the village of Hatt and the end of the road joint with NR 13.

The project road (Section 4) starts at the village of Hatt, then, climbs down the mountain along Wadi al Hat for about 2 kilometers. The road grazes the wadi bed in short distance at the village of Bilad Sayt then climbs up the ridge again.

The road alignment is interrupted by the deep valley and it is forced to detour. The road goes upstream to cross the wadi at Chainage 4.8 kilometer then comes back the

opposite of the valley. At this section, between Chainage 3.7 kilometer and 6.1 kilometer, the road faces very critical terrain condition with vertically standing cliff and steeply cut deep valley, named Wadi Bimah, such as that the mountain side slopes are overhanging, the road width is quite narrow, the shoulder is barely fixed by loose masonry and horizontal alignment just traces the topography without any relation to geometric requirements of road. Wadi Bimah and Wadi al Hat meet and become one stream at downstream beyond just few hundreds meters.

From Chainage 8.4 kilometer, the road passes inside, or side bank of, the wadi up to Chainage 12.9 kilometer. At the point of 12.9 kilometer the wadi flows down to the narrow chasm of the mountain. The road goes away from wadi and traverse the ridge to another wadi, named Wadi Bani Awf. From Chainage 13.8 kilometer to the end point of Phase 4, the road just follows and passes inside Wadi Bani Awf. The wadi is passing through the valley and is narrow and go zigzag at the most of the stretch, but occasionally becomes relatively wider.

The existing condition of the project road is shown in Figure 18.2-1.

End Point 28.3km

Rustaq

NR13

Al Awabi

Wadi Bani Awf at 27km

Wadi Bani Awf at 14km

Proposed Bridge Location

Wadi Bani Awf at 9km

Wadi al Hat & Bimah meet

Beginning Point 0km

Figure 18.2-1 Existing Road Condition

18.2.3 Proposed Road Alignment

The existing road passes through the limited space surrounded by cliffs and steep slopes of mountains. The peaks of the mountains adjacent to the road are over 1,000 meters high and many streams have carved the mountain slope. As the result of the investigation, it is assumed that the route of the planned road follow the existing road because preferable alternative route could not be found from the topographic map.

However, alteration of alignment is proposed at the critical road section between chainage 3.7 kilometer and 6.1 kilometer to avoid the risks of the stability of the road. As the alternative, this Study suggests crossing the deep valley with a bridge, span length of which becomes approximately 120 meters and bridge length is approximately 190 meters. In this Study, the arch bridge made by the pre-stressed concrete shall be adopted with the consideration on the appropriateness for that span length, suitability on the site condition and availability of the materials. This alternative is also short-cuts the road length by about 2 kilometers. Figure 18.2-2 shows the rough sketch of the proposed bridge.

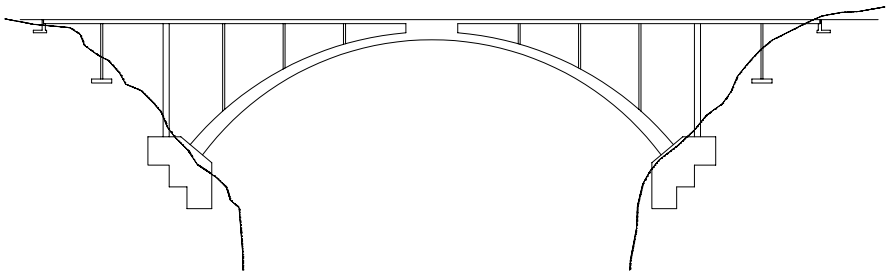


Figure 18.2-2 Proposed Bridge

The road section inside the wadi shall be closed to bank basically to secure sufficient cross-sectional area for the flood stream. The elevation of the road shall be raised by 1.0 meter on average from the river bed to keep the road surface above the water level during the flood usually experienced.

Figure 18.2-3 shows the proposed alignment of the project road.

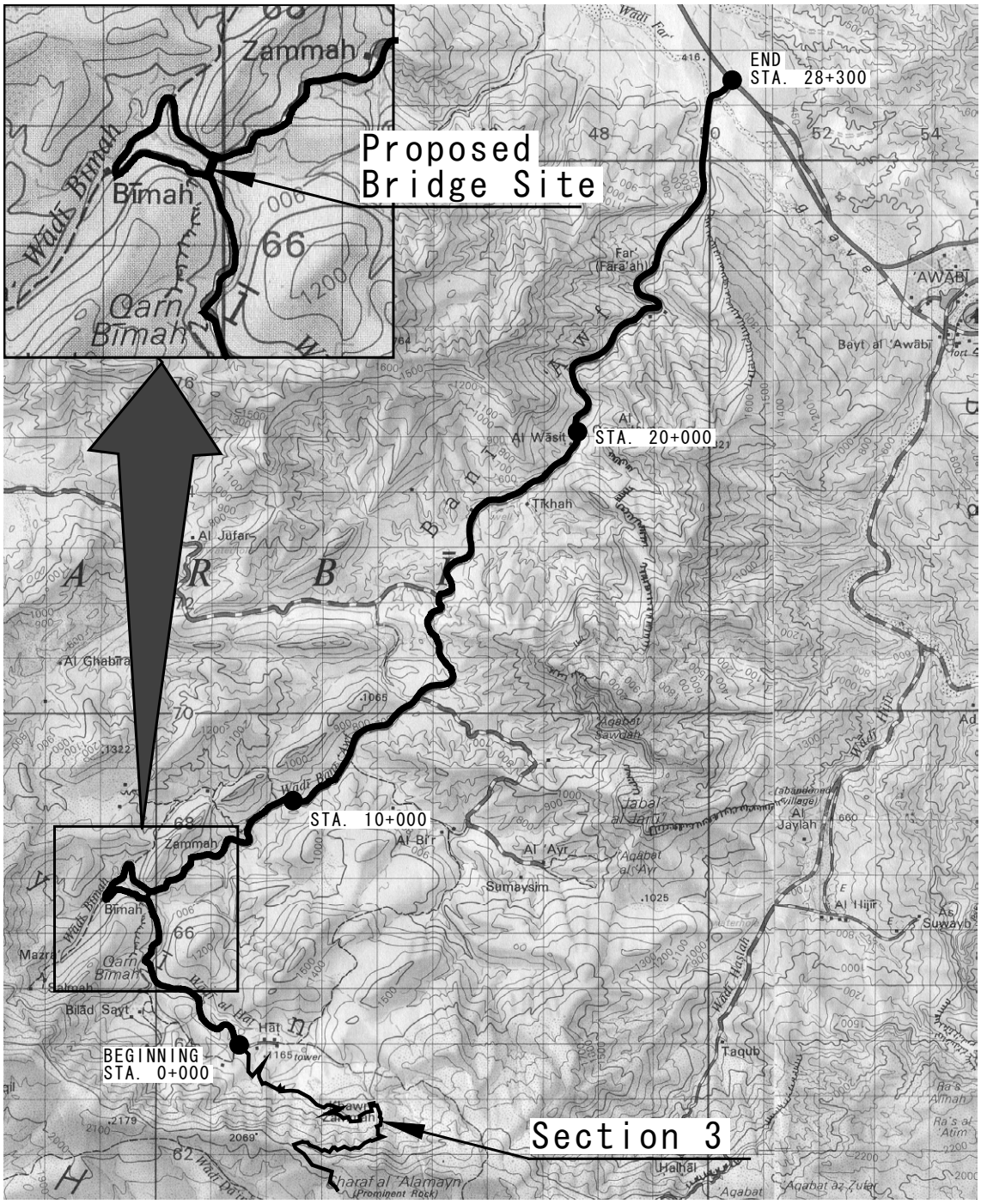


Figure 18.2-3 Proposed Alignment

18.2.4 Preliminary Design

The proposed cross sections follow the Highway Design Manual of Oman (HDM). As mentioned in HDM, the carriageway of secondary road shall be 7.0 meters and paved shoulder of 1.5 meters in width shall be provided on both sides in this project. Basically the verge of 2.0 meters in width shall be adopted on both sides as stated in HDM. But the verge will be omitted or narrowed in the mountainous terrain and rolling terrain,

where its vertical grade is steeper than 4 %, to avoid the erosion of unpaved verge surface and to install the side ditch on that space. The side ditches shall be lined by the grouted riprap on those sections to protect the pavement structure from the erosion.

Where the slope of the mountain is very steep, the retaining wall shall be adopted to secure the necessary road width. The retaining wall will be either gravity type or reverse T-shape type depending on the site condition, and guardrail or concrete barrier shall be installed. Inside the wadi, road embankment shall be protected from the flood stream by the grouted riprap.

As the result of the above consideration, the typical cross sections are proposed as shown in Figure 18.2-4.

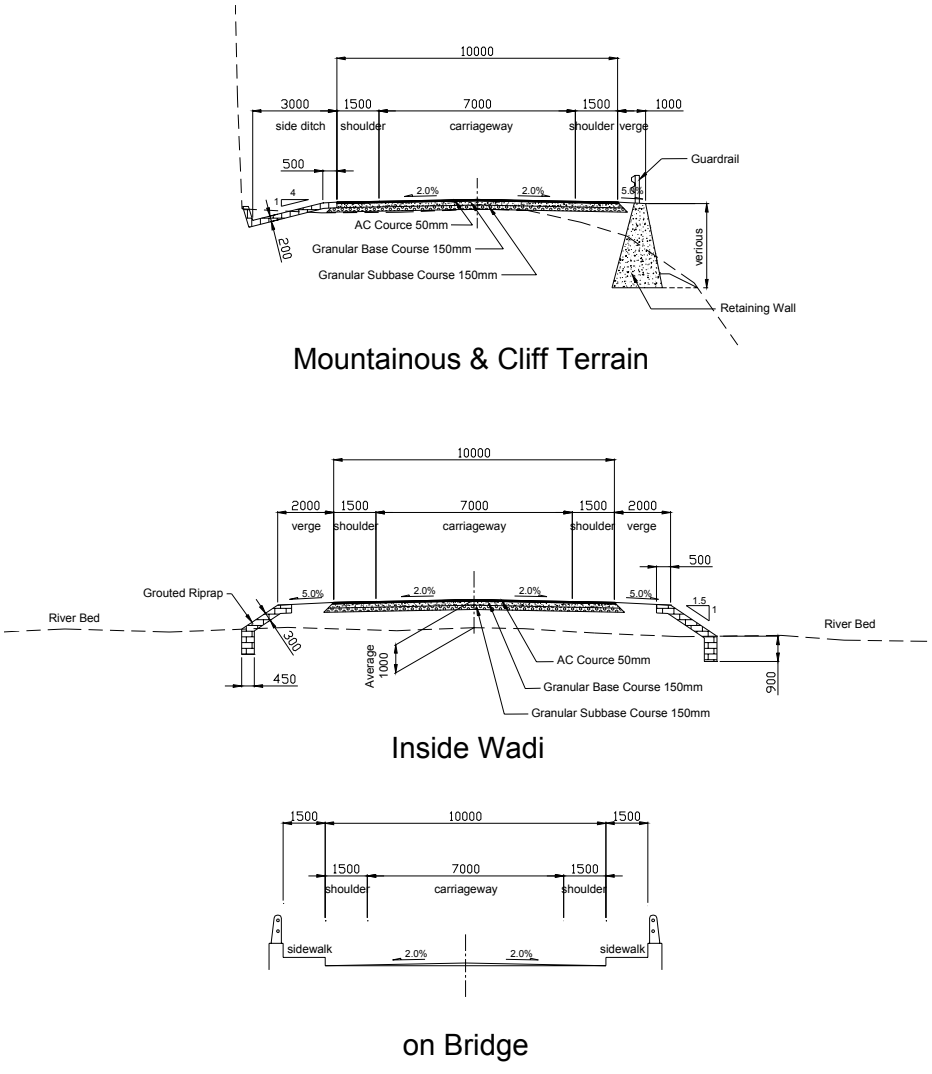


Figure 18.2-4 Typical Cross Sections

18.2.5 Pavement Design

The detail study for the pavement is not carried out in this Study because the traffic is forecasted to be small and bearing capacity of the subgrade seems to be high. Accordingly, the pavement structure similar to other secondary road may be adopted. In this Study, the same pavement structure of Section 3 of the same road, which is designed recently, is adopted.

18.2.6 Structure Design

HDM shows the standard drawings for the several types of structures, including retaining wall, cross drainage and slope protection, and they are used commonly in the projects whether they are under designing, construction or completed. In this Study, the structures are designed in accordance with HDM and the standard drawings of HDM are adopted in this Study for most of the cases.

18.2.7 Drainage and Cross Drainage Facilities

Through the site survey of the project road, necessary drainage facilities were studied and listed as shown in Table 18.2-1.

Table 18.2-1 List of the Drainage Facilities (1/2)

	Chainage	Drainage		Chainage	Drainage
1	0km+300	Pipe 1-900	21	5km+100	Box 3-3.0*3.0
2	0km+500	Pipe 1-1500	22	5km+400	Box 1-3.0*3.0
3	0km+800	Pipe 2-1500	23	5km+500	Pipe 1-900
4	0km+900	Pipe 1-1500	24	5km+900	Pipe 1-900
5	1km+200	Pipe 1-1500	25	6km+100	Bridge(Short Cut)
6	1km+300	Pipe 1-1500	26	6km+200	Pipe 1-900
7	1km+600	Pipe 1-1500	27	6km+500	Pipe 1-1500
8	1km+700	Pipe 1-1500	28	7km+000	Pipe 1-1500
9	2km+025	Irish Bridge (50m)	29	7km+200	Box 1-3.0*3.0
10	2km+225	Irish Bridge (50m)	30	7km+300	Pipe 2-1500
11	2km+400	Box 1-3.0*3.0	31	7km+500	Pipe 1-600
12	2km+700	Box 1-3.0*3.0	32	8km+120	Irish Bridge (40m)
13	3km+000	Pipe 1-1500	33	8km+740	Irish Crossing (80m)
14	3km+300	Pipe 1-1500	34	9km+130	Irish Crossing (60m)
15	3km+500	Pipe 1-900	35	9km+225	Irish Crossing (50m)
16	3km+700	Bridge(Short Cut)	36	9km+715	Irish Crossing (30m)
17	3km+900	Pipe 1-900	37	10km+700	Box 2-3.0*3.0
18	4km+100	Pipe 1-900	38	10km+930	Irish Crossing (60m)
19	4km+400	Pipe 1-900	39	11km+300	Box 3-3.0*3.0
20	4km+820	Irish Bridge (40m)	40	11km+735	Irish Crossing (70m)

Table 18.2-1 List of the Drainage Facilities (2/2)

	Chainage	Drainage		Chainage	Drainage
41	12km+130	Irish Crossing (60m)	56	18km+618	Irish Crossing (35m)
42	12km+335	Irish Crossing (70m)	57	19km+125	Irish Crossing (50m)
43	12km+913	Irish Bridge (25m)	58	19km+950	Irish Crossing (100m)
44	13km+400	Pipe 2-1500	59	20km+750	Irish Crossing (100m)
45	14km+115	Irish Crossing (30m)	60	21km+215	Irish Crossing (30m)
46	14km+600	Pipe 1-1500	61	21km+445	Irish Crossing (90m)
47	15km+100	Pipe 1-1500	62	21km+845	Irish Crossing (90m)
48	15km+340	Irish Crossing (80m)	63	22km+530	Irish Crossing (60m)
49	15km+530	Irish Crossing (60m)	64	24km+535	Irish Crossing (70m)
50	15km+845	Irish Crossing (90m)	65	24km+830	Irish Crossing (60m)
51	17km+140	Irish Crossing (80m)	66	25km+740	Irish Crossing (80m)
52	17km+730	Irish Crossing (60m)	67	27km+035	Irish Crossing (70m)
53	18km+120	Irish Crossing (40m)	68	27km+150	Irish Crossing (100m)
54	18km+200	Box 1-3.0*3.0	69	27km+800	Box 3-3.0*3.0
55	18km+430	Irish Crossing (60m)			

18.3 Preliminary Cost Estimation

18.3.1 Procedure of Project Cost Estimate

The procedure of project cost estimation is shown in Figure 18.3-1. The estimate is made based on the unit prices of construction material, labor costs and equipment costs which are obtained from the survey of the current market prices. The unit costs of major construction items are decided after comparing the estimated unit cost with latest bid prices.

The prices of items needed in the project, but not listed in the table are quoted from those available in Japan and converted to RO using the exchange rate of ; US$ 1.0 = RO 0.385 = JPY 108.

Engineering services cost is estimated as the percentage of the construction cost.

ROW acquisition cost for new roads and widening are not estimated because there is no necessity of new land acquisition for roads.

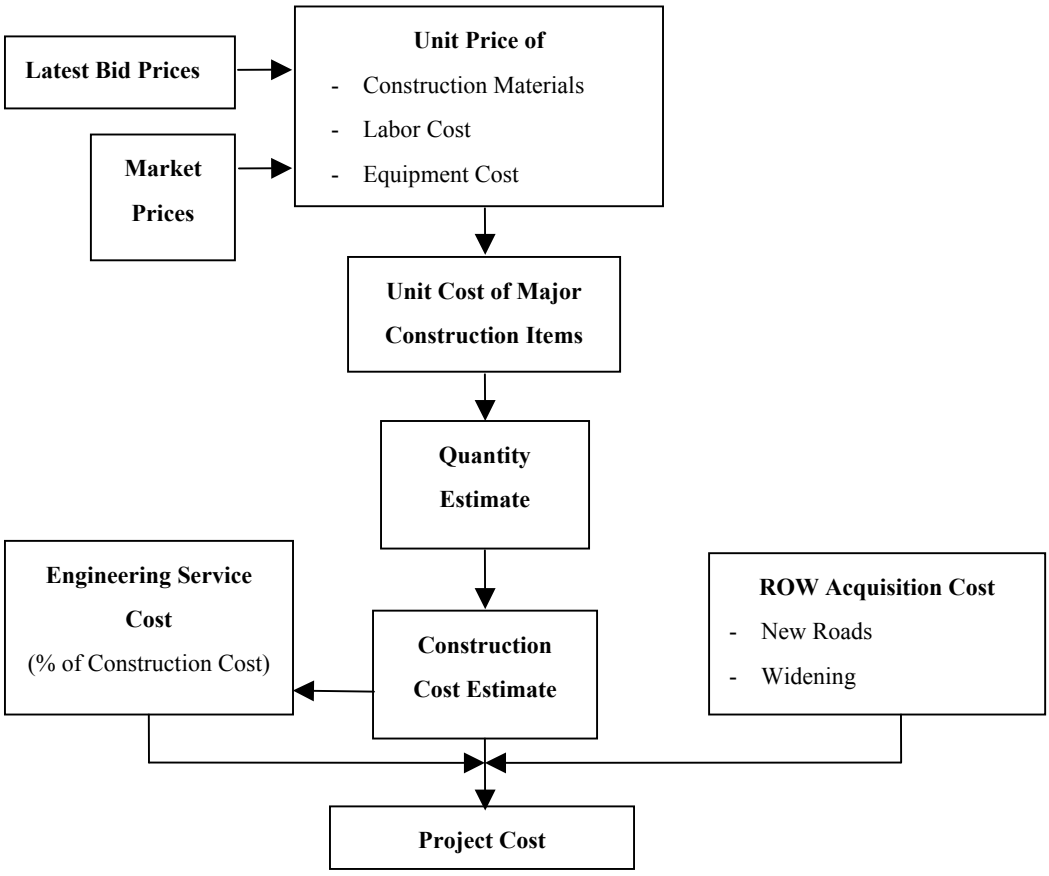


Figure 18.3-1 Procedure of Project Cost Estimate

18.3.2 Unit Price and Cost of Major Construction Items

Unit prices of major construction materials, labor cost and equipment cost, which are determined based on the investigation of the latest market prices, are shown in Tables 18.3-1, 18.3-2 and 18.3-3, respectively.

The major construction items are defined from "The Sultanate of Oman, General Specification for Roads, April 1994" and their unit costs of the road with and without the proposed bridge are presented in Table 18.3-4 and Table 18.3-5, respectively.

Table 18.3-1 Average Prices of Major Construction Materials (2004 Prices)

No.	Material Description	Unit	Unit Price (RO)
1	Aggregates for granular sub-base course	Cu.m.	3.000
2	Aggregate for aggregate base course	Cu.m.	3.000
3	Aggregates for bituminous base course	Cu.m.	3.000
4	Fine aggregate for concrete	Cu.m.	4.000
5	Coarse aggregate for concrete	Cu.m.	3.500
6	Stone for drainage, masonry and slope protection	Cu.m.	3.000
7	Asphalt cement, grade 60-70 on site	Ton	90.000
8	Asphalt cement, grade 50-60 on site	Ton	80.000
9	Emulsified asphalt, grade RS-1 on site	Ton	100.000
10	Cutback asphalt, MC and RC type on site	Ton	100.000
11	Portland cement on site	Ton	25.000
12	Deformed billet steel bars, AASHTO M31 grade 60 (High Yield) of any diameter	Ton	250.000
13	Deformed billet steel bars, AASHTO M31 grade 40 (High Yield) of any diameter	Ton	225.000
14	Highway signs	Sq.m.	50.000
15	Highway sign support	Nr.	25.000
16	Timber plank, on site	Cu.m	150.000
17	Timber props, on site	Cu.m.	150.000
18	Wire mesh gabion, on site	Ton	225.000
19	Explosive, on site	Kg	50.000
20	Gas oil, on site	Liter	0.500
21	Gasoline, Premium	Liter	0.120
22	Gasoline, Regular	Liter	0.114
23	Diesel	Liter	0.102

Source: Study Team Survey

Table 18.3-2 Labor Cost (2004 Prices)

No.	Labor Category	Unit	Unit Rate (RO)
1	Supervisor	Hour	3.000
2	Site Surveyor	Hour	3.000
3	Foreman	Hour	2.000
4	1st Class Operator	Hour	2.000
5	2nd Class Operator	Hour	1.800
6	Mechanic	Hour	1.700
7	Driver	Hour	1.800
8	Skilled Labor	Hour	1.200
9	Semi-skilled Labor	Hour	1.000
10	Mason	Hour	1.200
11	Painter	Hour	1.200
12	Carpenter	Hour	1.200
13	Steel Fixer	Hour	1.200
14	Electrician	Hour	1.200

Source: Study Team Survey

Table 18.3-3 Hourly Cost of Major Construction Equipments (2004 Prices)

No.	Construction Equipment	Hourly Cost (RO)
1	Motor grader from 100 HP to 120 HP	12.000
2	Motor grader from 120 HP to 150 HP	15.000
3	Tractor from 60 HP to 100 HP	12.000
4	Bulldozer with ripper from 100 HP to 150 HP	12.000
5	Bulldozer with ripper from 150 HP to 200 HP	16.000
6	Bulldozer with ripper from 200 HP to 250 HP	18.000
7	Bulldozer with ripper from 250 HP to 300 HP	20.000
8	Wheel Tractor up to 50 HP	8.000
9	Wheel Tractor over 50 HP	9.000
10	Motor scraper capacity up to 18 cu.m.	18.000
11	Motor scraper capacity 18 to 24 cu.m.	22.000
12	Sheeps foot roller from 5 to 10 ton	7.000
13	Vibratory compactor with prime mover up to 5 ton	5.000
14	Pneumatic compactor with prime mover from 30 to 50 ton	5.000
15	Pneumatic self-propelled roller from 15 to 20 ton	6.000
16	Tandem roller up to 8 ton	5.000
17	Tandem roller from 8 to 12 ton	7.000
18	Triaxle roller from 10 to 15 ton	8.000
19	Light frog-rammer 0.1 ton	1.000
20	Heavy frog-rammer 0.5 ton	1.500
21	Wheel loader 1.2 to 1.6 cu.m.	6.000
22	Wheel loader 1.6 to 2.5 cu.m.	8.000
23	Excavator up to 0.8 cu.m.	6.000
24	Excavator from 0.8 to 1.2 cu.m.	9.000
25	Bituminous mixing plant with batching apparatus up to 80 ton/hr	20.000
26	Bituminous mixing plant with batching apparatus 80 to 150 ton/hr	30.000
27	Finisher up to 80 ton/hr	10.000
28	Finisher from 80 to 120 ton/hr	12.000
29	Bitumen sprayer up to t ton	7.500
30	Tanker truck up to 6 cu.m.	5.500
31	Dump truck up to 10 ton	5.000
32	Dump truck from 10 ton to 15 ton	6.000
33	Screening plant from 80 to 100 ton/hr	18.000
34	Crushing plant up to 40 ton/hr	13.000
35	Crushing plant from 40 to 60 ton/hr	15.000
36	Air compressor up to 6000 l/m	2.500
37	Air compressor over 6000 l/m	4.000
38	Mechanical broom	4.000
39	Power water pump	1.500
40	Steel cutting machine	1.000
41	Steel bending machine	1.000
42	Belt conveyor	2.000
43	Concrete mixer up to 0.5 cu.m.	2.500
44	Concrete mixer over 0.5 cu.m.	4.000
45	Automatic concrete batch plant without mixing	16.000
46	Transmixer up to 5 cu.m.	15.000
47	Concrete vibrators	1.000
48	Crane up to 5 ton	5.000
49	Crane with boom and jib from 5 to 10 ton	10.000
50	Crane with boom and jib over 10 ton	15.000
51	Generator 60 ~ 75 Kw	2.500
52	Generator 100 Kw	5.000
53	Generator 150 ~ 200 Kw	9.000
54	Drilling Equipment	10.000
55	Gravel strewer	5.000
56	Asphalt cutter	2.000
57	Vehicle for foreman and surveyor	5.000

Source: Study Team Survey

Table 18.3-4 Unit Cost of Major Construction Items of the Road with the Proposed Bridge

No.	Description	Unit	Unit Cost (RO)	Foreign component		Local Component		Taxes	
	200 EARTHWORKS								
203	**Earthworks Excavation**								
	Suitable excavation to embankment	Cu. m.	1.944	1.034	53%	0.859	44%	0.052	3%
	Suitable excavation to waste	Cu. m.	1.733	0.920	53%	0.767	44%	0.046	3%
	Borrow excavation to embankment	Cu. m.	3.660	1.300	36%	2.295	63%	0.065	2%
206	**Excavation and Backfilling for Structures**								
	Structural excavation in soils to a depth of 2m.	Cu. m.	1.475	0.758	51%	0.679	46%	0.038	3%
	Structural excavation in rock to a depth of 2m.	Cu. m.	2.625	1.392	53%	1.164	44%	0.070	3%
	Structural excavation in rock to a depth more than 2m.	Cu. m.	4.043	1.855	46%	2.095	52%	0.093	2%
	300 GRANULAR AND STABILIZED SUBBASE, BASECOURSE AND STABILIZED SUBGRADE								
302	**Granular Subbase**								
	Class A Subbase	Cu. m.	5.000	2.094	42%	2.801	56%	0.105	2%
	Class B Subbase	Cu. m.	4.000	1.675	42%	2.241	56%	0.084	2%
303	**Aggregate Basecourse**								
	Class A Basecourse	Cu. m.	5.000	2.112	42%	2.783	56%	0.106	2%
	Class B Basecourse	Cu. m.	4.000	1.689	42%	2.226	56%	0.084	2%
	400 BITUMINOUS PAVEMENT								
401	**Bituminous Prime Coat and Tack Coat**								
	Prime Coat such as MC70	Kg	0.120	0.078	65%	0.039	32%	0.004	3%
	Tack Coat such as RC250	Kg	0.150	0.097	65%	0.048	32%	0.005	3%
402	**Bituminous Basecourse**								
	Bituminous Basecourse	Cu. m.	17.000	10.893	64%	5.563	33%	0.545	3%
405	**Bituminous Wearing Course**								
	Bituminous Wearing Course	Cu. m.	17.000	10.893	64%	5.563	33%	0.545	3%
	500 CONCRETE AND CONCRETE STRUCTURES								
504	**Concrete for Structures**								
	Concrete Class 28/20	Cu. m.	40.000	13.954	35%	25.348	63%	0.698	2%
509	**Reinforcing Steel**								
	High yield steel bars	ton	250.000	153.428	61%	88.901	36%	7.671	3%
	Mild steel bars	ton	250.000	152.690	61%	89.676	36%	7.634	3%
	800 DRAINAGE AND SERVICE DUCTS								
801	**Pipe Culverts**								
	Reinforced Concrete Pipe Culvert 600 mm	Lin. m.	35.000	18.270	52%	15.817	45%	0.914	3%
	Reinforced Concrete Pipe Culvert 900 mm	Lin. m.	75.000	39.150	52%	33.893	45%	1.958	3%
	Reinforced Concrete Pipe Culvert 1500 mm	Lin. m.	155.000	80.910	52%	70.045	45%	4.046	3%
	900 SLOPE PROTECTION AND STABILIZATION								
901	**Rip Rap**								
	Loose stone riprap Class A	Cu. m.	6.000	2.477	41%	3.399	57%	0.124	2%
	Loose stone riprap Class B	Cu. m.	6.000	2.477	41%	3.399	57%	0.124	2%
	Mortared stone riprap	Cu. m.	15.000	4.438	30%	10.340	69%	0.222	1%
902	**Gabions**								
	Gabions	Cu. m.	13.000	4.977	38%	7.774	60%	0.249	2%
906	**Ditch lining**								
	Ditch lining (150mm thick)	Sq. m.	2.000	0.573	29%	1.399	70%	0.029	1%
	1200 SIDEWALKS, PAVED AREAS AND CURBS								
1202	**Curbs**								
	Precast concrete curb, Class 28/20 non-mountable type	Lin. m.	5.000	1.744	35%	3.169	63%	0.087	2%
	Precast concrete curb, Class 28/20 mountable type	Lin. m.	5.000	1.744	35%	3.169	63%	0.087	2%
	Precast concrete curb, Class 28/20 lip type	Lin. m.	5.000	1.744	35%	3.169	63%	0.087	2%
	1300 SAFETY BARRIERS, DELINEATORS AND FENCES								
1301	**Corrugated Steel Beam Safety Barrier**								
	Safety barrier beam (Class B, W-section)	Lin. m.	5.000	3.610	72%	1.210	24%	0.180	4%
	Safety barrier post (Type C) including foundation	Nr.	12.000	8.664	72%	2.903	24%	0.433	4%
	End anchorage (ramp down), including post (Type C) and foundation	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
	W-beam terminal section								
	Re-fixing of safety barrier beam	Nr.	15.000	10.830	72%	3.629	24%	0.541	4%
	Re-fixing of safety barrier post including foundation	Lin. m.	0.500	0.361	72%	0.121	24%	0.018	4%
	Re-fixing of end anchorage (ramp down) including posts	Nr.	3.000	2.166	72%	0.726	24%	0.108	4%
	Re-fixing of W-beam terminal section	Nr.	16.000	11.552	72%	3.870	24%	0.578	4%
1302	**Concrete safety barrier**								
	Concrete safety barrier (Type A)	Lin. m.	55.000	19.186	35%	34.854	63%	0.959	2%
	Concrete safety barrier (Type B)	Lin. m.	30.000	10.465	35%	19.011	63%	0.523	2%
1303	**Reflectorized Markers for safety barriers**								
	Reflectorized markers (red) attached to Guardrail	Nr.	4.000	2.888	72%	0.968	24%	0.144	4%
	Reflectorized markers (red) attached to concrete barrier	Nr.	3.000	2.166	72%	0.726	24%	0.108	4%
1304	**Delineators**								
	Flexible delineators	Nr.	12.000	8.664	72%	2.903	24%	0.433	4%
	Irish crossing markers	Nr.	35.000	25.270	72%	8.467	24%	1.263	4%
	Irish crossing water depth gauges	Nr.	42.000	30.324	72%	10.160	24%	1.516	4%
	1400 HIGHWAY SIGNS AND ROAD MARKINGS								
1401	**Highway Signs**								
	Triangular, side 900mm	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
	Triangular, side 1100mm	Nr.	30.000	21.660	72%	7.257	24%	1.083	4%
	Triangular, side 1200mm	Nr.	40.000	28.880	72%	9.676	24%	1.444	4%
	Circular, diameter 900mm	Nr.	30.000	21.660	72%	7.257	24%	1.083	4%
	Circular, diameter 1200mm	Nr.	85.000	61.370	72%	20.562	24%	3.068	4%
	Rectangular sign	Sq.m.	50.000	36.100	72%	12.095	24%	1.805	4%
	Kilometer post (sign No. 323)	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
	Sign post support assembly, (Type 1A)	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
	Sign post support assembly, (Type 1B)	Nr.	54.000	38.988	72%	13.063	24%	1.949	4%
	Sign post support assembly, (Type II)	Nr.	68.000	49.096	72%	16.450	24%	2.455	4%
	Sign post support assembly, (Type IIIA)	Nr.	150.000	108.299	72%	36.286	24%	5.415	4%
	Sign post support assembly, (Type IIIB)	Nr.	155.000	111.909	72%	37.495	24%	5.595	4%
	Re-fixing of removed highway sign (any size with single post)	Nr.	20.000	14.440	72%	4.838	24%	0.722	4%
	Re-fixing of removed highway sign (any size with multiple post)	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
1402	**Road Markings**								
	Traffic lines (mechanically sprayed)	Sq. m.	1.600	1.155	72%	0.387	24%	0.058	4%
	Curb painting (black and yellow)	Sq. m.	1.000	0.722	72%	0.242	24%	0.036	4%
	Reflecting road studs (double face)	Nr.	3.500	2.527	72%	0.847	24%	0.126	4%

Table 18.3-5 Unit Cost of Major Construction Items of the Road without the Proposed Bridge

No.	Description	Unit	Unit Cost (RO)	Foreign component		Local Component		Taxes	
	200 EARTHWORKS								
203	**Earthworks Excavation**								
	Suitable excavation to embankment	Cu. m.	2.109	1.122	53%	0.931	44%	0.056	3%
	Suitable excavation to waste	Cu. m.	1.731	0.919	53%	0.766	44%	0.046	3%
	Borrow excavation to embankment	Cu. m.	3.660	1.300	36%	2.295	63%	0.065	2%
206	**Excavation and Backfilling for Structures**								
	Structural excavation in soils to a depth of 2m.	Cu. m.	1.475	0.758	51%	0.679	46%	0.038	3%
	Structural excavation in rock to a depth of 2m.	Cu. m.	2.625	1.392	53%	1.164	44%	0.070	3%
	Structural excavation in rock to a depth more than 2m.	Cu. m.	4.043	1.855	46%	2.095	52%	0.093	2%
	300 GRANULAR AND STABILIZED SUBBASE, BASECOURSE AND STABILIZED SUBGRADE								
302	**Granular Subbase**								
	Class A Subbase	Cu. m.	5.000	2.094	42%	2.801	56%	0.105	2%
	Class B Subbase	Cu. m.	4.000	1.675	42%	2.241	56%	0.084	2%
303	**Aggregate Basecourse**								
	Class A Basecourse	Cu. m.	5.000	2.112	42%	2.783	56%	0.106	2%
	Class B Basecourse	Cu. m.	4.000	1.689	42%	2.226	56%	0.084	2%
	400 BITUMINOUS PAVEMENT								
401	**Bituminous Prime Coat and Tack Coat**								
	Prime Coat such as MC70	Kg	0.120	0.078	65%	0.039	32%	0.004	3%
	Tack Coat such as RC250	Kg	0.150	0.097	65%	0.048	32%	0.005	3%
402	**Bituminous Basecourse**								
	Bituminous Basecourse	Cu. m.	17.000	10.893	64%	5.563	33%	0.545	3%
405	**Bituminous Wearing Course**								
	Bituminous Wearing Course	Cu. m.	17.000	10.893	64%	5.563	33%	0.545	3%
	500 CONCRETE AND CONCRETE STRUCTURES								
504	**Concrete for Structures**								
	Concrete Class 28/20	Cu. m.	40.000	13.954	35%	25.348	63%	0.698	2%
509	**Reinforcing Steel**								
	High yield steel bars	ton	250.000	153.428	61%	88.901	36%	7.671	3%
	Mild steel bars	ton	250.000	152.690	61%	89.676	36%	7.634	3%
	800 DRAINAGE AND SERVICE DUCTS								
801	**Pipe Culverts**								
	Reinforced Concrete Pipe Culvert 600 mm	Lin. m.	35.000	18.270	52%	15.817	45%	0.914	3%
	Reinforced Concrete Pipe Culvert 900 mm	Lin. m.	75.000	39.150	52%	33.893	45%	1.958	3%
	Reinforced Concrete Pipe Culvert 1500 mm	Lin. m.	155.000	80.910	52%	70.045	45%	4.046	3%
	900 SLOPE PROTECTION AND STABILIZATION								
901	**Rip Rap**								
	Loose stone riprap Class A	Cu. m.	6.000	2.477	41%	3.399	57%	0.124	2%
	Loose stone riprap Class B	Cu. m.	6.000	2.477	41%	3.399	57%	0.124	2%
	Mortared stone riprap	Cu. m.	15.000	4.438	30%	10.340	69%	0.222	1%
902	**Gabions**								
	Gabions	Cu. m.	13.000	4.977	38%	7.774	60%	0.249	2%
906	**Ditch lining**								
	Ditch lining (150mm thick)	Sq. m.	2.000	0.573	29%	1.399	70%	0.029	1%
	1200 SIDEWALKS, PAVED AREAS AND CURBS								
1202	**Curbs**								
	Precast concrete curb, Class 28/20 non-mountable type	Lin. m.	5.000	1.744	35%	3.169	63%	0.087	2%
	Precast concrete curb, Class 28/20 mountable type	Lin. m.	5.000	1.744	35%	3.169	63%	0.087	2%
	Precast concrete curb, Class 28/20 lip type	Lin. m.	5.000	1.744	35%	3.169	63%	0.087	2%
	1300 SAFETY BARRIERS, DELINEATORS AND FENCES								
1301	**Corrugated Steel Beam Safety Barrier**								
	Safety barrier beam (Class B, W-section)	Lin. m.	5.000	3.610	72%	1.210	24%	0.180	4%
	Safety barrier post (Type C) including foundation	Nr.	12.000	8.664	72%	2.903	24%	0.433	4%
	End anchorage (ramp down), including post (Type C) and foundation	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
	W-beam terminal section								
	Re-fixing of safety barrier beam	Nr.	15.000	10.830	72%	3.629	24%	0.541	4%
	Re-fixing of safety barrier post including foundation	Lin. m.	0.500	0.361	72%	0.121	24%	0.018	4%
	Re-fixing of end anchorage (ramp down) including posts	Nr.	3.000	2.166	72%	0.726	24%	0.108	4%
	Re-fixing of W-beam terminal section	Nr.	16.000	11.552	72%	3.870	24%	0.578	4%
1302	**Concrete safety barrier**								
	Concrete safety barrier (Type A)	Lin. m.	55.000	19.186	35%	34.854	63%	0.959	2%
	Concrete safety barrier (Type B)	Lin. m.	30.000	10.465	35%	19.011	63%	0.523	2%
1303	**Reflectorized Markers for safety barriers**								
	Reflectorized markers (red) attached to Guardrail	Nr.	4.000	2.888	72%	0.968	24%	0.144	4%
	Reflectorized markers (red) attached to concrete barrier	Nr.	3.000	2.166	72%	0.726	24%	0.108	4%
1304	**Delineators**								
	Flexible delineators	Nr.	12.000	8.664	72%	2.903	24%	0.433	4%
	Irish crossing markers	Nr.	35.000	25.270	72%	8.467	24%	1.263	4%
	Irish crossing water depth gauges	Nr.	42.000	30.324	72%	10.160	24%	1.516	4%
	1400 HIGHWAY SIGNS AND ROAD MARKINGS								
1401	**Highway Signs**								
	Triangular, side 900mm	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
	Triangular, side 1100mm	Nr.	30.000	21.660	72%	7.257	24%	1.083	4%
	Triangular, side 1200mm	Nr.	40.000	28.880	72%	9.676	24%	1.444	4%
	Circular, diameter 900mm	Nr.	30.000	21.660	72%	7.257	24%	1.083	4%
	Circular, diameter 1200mm	Nr.	85.000	61.370	72%	20.562	24%	3.068	4%
	Rectangular sign	Sq.m.	50.000	36.100	72%	12.095	24%	1.805	4%
	Kilometer post (sign No. 323)	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
	Sign post support assembly, (Type 1A)	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
	Sign post support assembly, (Type 1B)	Nr.	54.000	38.988	72%	13.063	24%	1.949	4%
	Sign post support assembly, (Type II)	Nr.	68.000	49.096	72%	16.450	24%	2.455	4%
	Sign post support assembly, (Type IIIA)	Nr.	150.000	108.299	72%	36.286	24%	5.415	4%
	Sign post support assembly, (Type IIIB)	Nr.	155.000	111.909	72%	37.495	24%	5.595	4%
	Re-fixing of removed highway sign (any size with single post)	Nr.	20.000	14.440	72%	4.838	24%	0.722	4%
	Re-fixing of removed highway sign (any size with multiple post)	Nr.	25.000	18.050	72%	6.048	24%	0.902	4%
1402	**Road Markings**								
	Traffic lines (mechanically sprayed)	Sq. m.	1.600	1.155	72%	0.387	24%	0.058	4%
	Curb painting (black and yellow)	Sq. m.	1.000	0.722	72%	0.242	24%	0.036	4%
	Reflecting road studs (double face)	Nr.	3.500	2.527	72%	0.847	24%	0.126	4%

18.3.3 Construction Cost

Estimated construction cost of the road with and without the proposed bridge are presented in Table 18.3-6 and Table 18.3-7, respectively. Detailed cost estimate of them are shown in Annex 18-1 and Annex 18-2, respectively. The construction cost of the road with the bridge was estimated at RO 10,743,000, composed of 58.0% of a foreign currency component (or RO 6,231,000), 39.1% of a local currency component (or RO 4,201,000) and 2.9% of a tax component (or RO311,000). And the construction cost of the road without the bridge was estimated at RO 7,866,000, composed of 52.2% of a foreign currency component (or RO 4,106,000), 45.2% of a local currency component (or RO 3,555,000) and 2.6% of a tax component (or RO205,000). Indirect costs (contingency) was assumed at 10% of direct cost, referring to the latest bid prices.

Table 18.3-6 Construction Cost (RO 1,000) of the Road with the Proposed Bridge

	Foreign	Local	Tax	Total
Amount	6,231 (58.0%)	4,201 (39.1%)	311 (2.9%)	10,743 (100%)

Table 18.3-7 Construction Cost (RO 1,000) of the Road without the Proposed Bridge

	Foreign	Local	Tax	Total
Amount	4,106 (52.2%)	3,555 (45.2%)	205 (2.6%)	7,866 (100%)

18.3.4 Engineering Service and Construction Supervision Cost

The engineering services cost covering detailed design (D/D) and construction supervision cost (C/S) is estimated as a certain percent of the project construction cost. The investigation of the recent projects in the Sultanate of Oman shows that the current percents for D/D and C/S are about 3% and 4%, respectively. Estimated engineering services and construction cost of the road with and without the bridge are presented in Table 18.3-8 and Table 18.3-9, respectively.

Table 18.3-8 Engineering Services and Construction Supervision Cost (RO 1,000) of the Road with the Proposed Bridge

	Foreign	Local	Tax	Total
Detailed Design	258 (80.0%)	32 (10.0%)	32 (10.0%)	322 (100%)
Construction Supervision	344 (80.0%)	43 (10.0%)	43 (10.0%)	430 (100%)
Total	602 (80.0%)	75 (10.0%)	75 (10.0%)	752 (100%)

Table 18.3-9 Engineering Services and Construction Supervision Cost (RO 1,000) of the Road without the Proposed Bridge

	Foreign	Local	Tax	Total
Detailed Design	188 (80.0%)	24 (10.0%)	24 (10.0%)	236 (100%)
Construction Supervision	251 (80.0%)	32 (10.0%)	32 (10.0%)	315 (100%)
Total	439 (80.0%)	56 (10.0%)	56 (10.0%)	551 (100%)

18.3.5 Summary of Project Costs

Summary of Project Cost of the road with and without the bridge are shown in Table 18.3-10 and Table 18.3-11, respectively.

Table 18.3-10 Summary of Project Cost (RO 1,000) of the Road with the Proposed Bridge

	Foreign	Local	Tax	Total
Detailed Design	258 (80.0%)	32 (10.0%)	32 (10.0%)	322 (100%)
Construction	6,231 (58.0%)	4,201 (39.1%)	311 (2.9%)	10,743 (100%)
Construction Supervision	344 (80.0%)	43 (10.0%)	43 (10.0%)	430 (100%)
Total	6,833 (59.4%)	4,276 (37.2%)	386 (3.4%)	11,495 (100%)

Table 18.3-11 Summary of Project Cost (RO 1,000) of the Road without the Proposed Bridge

	Foreign	Local	Tax	Total
Detailed Design	188 (80.0%)	24 (10.0%)	24 (10.0%)	236 (100%)
Construction	4,106 (52.2%)	3,555 (45.2%)	205 (2.6%)	7,866 (100%)
Construction Supervision	251 (80.0%)	32 (10.0%)	32 (10.0%)	315 (100%)
Total	4,545 (54.0%)	3,611 (42.9%)	261 (3.1%)	8,417 (100%)

18.4 ENVIRONMENTAL CONSIDERATIONS AND TOR FOR EIA

18.4.1 Environmental Considerations

1) General

The objectives of environmental considerations at the stage of the "Pre-Feasibility Study (Pre-F/S)" are:

- To confirm the results of the "Initial Environmental Examination (IEE)";
- To clarify present conditions in the project site and specific environmental impacts due to proposed road construction;
- To re-evaluate comprehensively proposed project road; and
- To provide the "Terms of Reference (TOR)" for EIA in the next "Feasibility Study".

The examined environmental considerations are:

1. Review of result of the IEE with data and information concerning the project,
2. Environmental investigation at the project site using "Environmental Checklist" (refer to Table 12.1-1),
3. Analysis of environmental conditions and impacts,
4. Comprehensive evaluation, and
5. Provision of TOR for EIA.

The content of the site investigation consists of the following environmental items:

(1) Air pollution
(2) Effluent
(3) Noise and vibration
(4) Land subsidence
(5) Topography and geology
(6) Soil and soil erosion
(7) Hydrology and groundwater
(8) Ecosystem, flora and fauna
(9) Landscape (including coastal zone)
(10) Regional development on the natural environment
(11) Hazards
(12) Other impacts on the natural environment
(13) Wastes
(14) Cultural heritage

(15) Regional development on the social environment
(16) Other impacts on the social environment

2) Environmental checklist for the project "HAMRA - RUSTAQ ROAD"

More detailed environmental investigation, analysis and comprehensive evaluation for the road section IV between Hatt and Ar Rustaq, a part of project road of Hamra - Rustaq road, were carried out using the environmental checklist. The results of investigation and evaluation are shown in Annex 18-3.

Consequently, environmental impacts due to the proposed road are likely to occur on the environmental items of Air Pollution, Noise, Topography and Geology, Soil, Eco-system, Flora and Fauna, Cultural heritage, and Other Impacts on Social Environment.

a. Air pollution

- Present condition:

Air pollution at present in the site is not significant, because very low traffic volume and no other existing exhaust source. Several villages and small settlements are located on the Lowermost Terrace along the Wadi Hatt and Wadi Bani Awf. Topography around the villages and settlements is featured very narrow wadi channel, particularly around Zammah and Far villages.

- Impacts with project:

The traffic volume of project road is anticipated to increase to approximately 10,000 veh/day. Most of the road sections will not be affected; however around villages and settlements located along narrow wadi channel, air quality is likely to deteriorate as a result of increased exhaust pollutants due to longer retention time, where topographical feature shows closed space.

- Evaluation: 1~2:

Slight to moderate impact on air quality due to increased traffic volume is evaluated.

b. Noise pollution

- Present condition:

Noise pollution at present in the site is not significant, because very low traffic volume and no other noise source. Several villages and small settlements are located on the Lowermost Terrace along Wadi Hatt and Wadi Bani Awf.

Topography at the villages and settlements is featured with very narrow wadi channel, particularly around Zammah and Far villages.

- Prediction with project:

The traffic volume of project road is anticipated to be increased approximately 10,000 veh/day. Most of theroad sections will not be affected because of open space; however around villages and settlements located along narrow wadi channel, noise is likely to increase because of short distance away from project road and topographically closed space, which has cliff in both sides. The sound will echo again by cliff.

- Evaluation: 1~2:

Slight to moderate impact to noise due to increased traffic volume.

c. Topography and Geology

- Present condition:

Topography:

The project area is located in the central part of Al Hajar Al Gharbi Mountains. Mountain Jabal Shams, being the highest peak in Oman, 3,009m above sea level, is located 10km west of the area and mountain ridge from Jabal Shams is connected to the project area.

Southern slope of the Al Jabal Al Akdar mountain ridge is characterized by large scale of cuesta topography showing gentle slope. On the contrary, northern slope of Al Jabal Al Akhdar mountain ridge is characterized by steep slope to vertical cliff as the cuesta topography. The project road section belongs to the northern steep slope terrain.

1. From 0 km (Start point: Hat village) to 15.3 km (Junction to Fashah):

The road section, marked by rugged and steep slope topography, belongs to high to moderate relief of mountain and passes along Wadi al Hatt and Wadi Bani Awf. V-shape deeply incised valleys and likely oddly shape rock outcroppings show in many places.

2. From 15.3 km to 28.3 km (End point):

This road section is also marked by rugged mountainous terrain and belongs to the moderate and low relief of mountain. The section passes along wadi channel of Wadi Bani Awf. Around end point of the road, topography changes to lower hilly and flat terrain.

Geology:

The project area crossing Al Jabal Al Akdar Mountains are continuously cropped out the Autochthonous Units, consisting of the Huqf Group of End-Protoezoic to Cambrian age and Akhdar Group, Sahtan Group, Kahmah Group and Wasia Group ranging in age from Late Permian to Middle Cretaceous. The Huqf Group is intensely metamorphosed and shows fine schistose. The geological structure clearly shows anticline deformation (dome structure) in large scale. Igneous rocks originated from ancient ocean floor, so-called Samail Ophiolite, are locally found near the end point of project road.

- Impacts with project:

The project will require massive excavation and embankment for paved 2-lane road construction, even if the road alignment mostly follows along the existing alignment. Hence, large to small scale alteration of topography will occur in many places. In addition, much cuttings caused in the slope will be generally dumped to the slope side, so that topographically larger area more than right-of-way (ROW) is likely to be irreversible altered.

- Evaluation: 1~2:

Slight to moderate impact due to road construction.

d. Soil

- Present condition:

Soil is poorly developed, but alluvial soil is locally found in the wadi and terraces. Farmlands in villages and settlements use these surface soils.

- Impacts with project:

The existing project road mostly passes along the wadi channels, so that the area of ROW and working site will be altered of surface soil. In addition, much cuttings caused in the slope will be generally dumped to the slope side, so that topographically larger area more than ROW is likely to be irreversible altered.

- Evaluation: 1~2:

Slight to moderate impact to surface soil due to road construction.

e. Eco-system, Flora and Fauna

- Present condition:

Flora:

Vegetation is found along the entire stretch of the project area. The lower lying hills have less vegetative cover than the higher areas, except for depressions and wadi flow channels. The vegetation can be classified as an open xenomorphic *Euphorbia* community type. Much of this area represents a good example of undisturbed habitat in northern Oman.

Fauna:

Wildlife known to the area may include the Arabian Leopard, Gazelle, Arabian Tahr and other fauna such as the red fox, etc. The IUCN red list of threatened animals (IUCN 1990) describes the mountain gazelle as vulnerable. Leopard and the Tahr are considered endangered.

- Impacts with project:

Any development in the area will be considered as having a significant impact as a result of the valuable nature of the habitat, because of rapidly increase of traffic volume in future.

Whilst the area does not have official reserve status, permits are required to enter some areas. This area could be one of the protection areas proclaimed as Nature Reserve in near future.

- Evaluation: 2:

Moderate impact to eco-system, flora and fauna due to road construction. It is necessary to carry out detailed investigation concerning eco-system, flora and fauna in the area, particularly relationship between Al Jabal Al Akdar area and project area before construction or during EIA.

f. Other Impacts on Social Environment

- Present condition:

There are several villages and small settlements with farmlands and a number of domestic animals along the route shown as below.

0 km point: Junction to Hat village.
1.5 km point: 6 houses and Date farms.
5.1km point: Bimah settlement.
5.1km point: Zammah village.
13.4km point: 3 houses settlement with small farm.
18.3km: Teekah village, farm and Medical office.
20.4km point: Al Wasit settlement with small date farm.
23.9 km point: 2 houses settlement with small date farm.
25.6~26.1km point: Far village.
28.3km point: Junction of NR No.13, Substation.

- Impacts with project:

The existing and proposed road passes nearby the villages and farmland. As high traffic volume is predicted, zone around villages and settlements as well as domestic animals may face the chance of traffic accidents.

- Evaluation: 1~2:

Slight to moderate impact as increase of chance of traffic accidents to social environment due to road construction.

h. Other environmental items: Not significant impact.

3) Results of IEE

The comprehensive evaluation for the Hamra - Rustaq Road is concluded to be 2 as impact rating; summarized in Table 18.4-1. Hence, the implementation of comprehensive EIA before road construction is recommended.

Table 18.4-1 Results of IEE on the Hamra - Rustaq Road

- Air Pollution	1~2	- Increased traffic volume
- Noise	1~2	- Increased traffic volume
- Topography and Geology	1~2	- Alteration of topography
- Soil	1~2	- Alteration of topography
- Eco-system, Flora and Fauna	2	- High potential of various species of flora and fauna - Increase of wastes due to increase of visitors - Increased traffic volume
- Other Impacts on Social Environment	1~2	- Increase of chance of traffic accidents due to increased traffic volume
- Other items	1	

Comprehensive Evaluation	2
Recommendations *1	Recommended to carry out EIA

Note *1 : Comprehensive Evaluation

1 : None to slight impacts : No need to carry out EIA or need to carry out partial EIA after scoping
1~2 : Small impacts : Recommended to carry out partial EIA on assigned items after scoping
2 : Moderate impacts : Recommended to carry out EIA
2~3 : Relatively significant impacts: Recommended to carry out EIA
3 : Significant impacts : Recommended to carry out EIA

18.4.2 Terms of Reference for the Project

Terms of reference (TOR) on the Environmental Impact Assessment of the Hamra - Rustaq Road, Sultanate of Oman, are shown in Annex 18-4.

18.5 PROJECT EVALUATION

18.5.1 General

The objective of this section is to examine viability of the improvement plan of Al Hamra - Rustaq Road from viewpoint of national economy of Oman.

In order to achieve the objective, the following steps are carried out;

Step 1: Traffic demand forecast on the Project

Step 2: Estimation of economic benefit based on traffic demand on the Project Road and unit vehicle operating cost

Step 3: Estimation of economic cost based on the estimated financial cost mentioned in Section 18.3.

Step 4: Calculation of economic indicators using the economic benefit and economic cost.

Step 5: Economic Evaluation of the Project Road.

Step 6: Sensitivity analysis to be made by varying factors of influenced to economic indicators such as the economic benefit and economic cost

Step 7: Future socio-economic framework in the influence area of the Project Road

Step 8: Evaluation from technical and socio-economic view points

Step 9: Overall evaluation

Figure 18.5-1 shows the procedure for project evaluation.

18.5.2 Traffic Demand Forecast

Future traffic demands forecasted in a form of OD matrix in the years 2010, 2020 and 2030 are assigned on the road network to estimate traffic volume on the Al Hamra - Rustaq Road. The estimated traffic volumes on the Road for the case of 'with' the project are summarized in Table 18.5-1.

Table 18.5-1 Traffic Volume on Hamra-Rustaq Road (PCU / Day)

	2010	2020	2030	AAGR (%)	
				'10-'20	'20-'30
Hamra – Wilayah Boarder	2,974	5,978	11,044	7.2	6.3
Wilayah Border – Rustaq	2,878	6,122	11,058	7.8	6.1

Tables 18.5-2 and 18.5-3 show the estimated total vehicle kilometers and total vehicle hours of the Road, respectively.

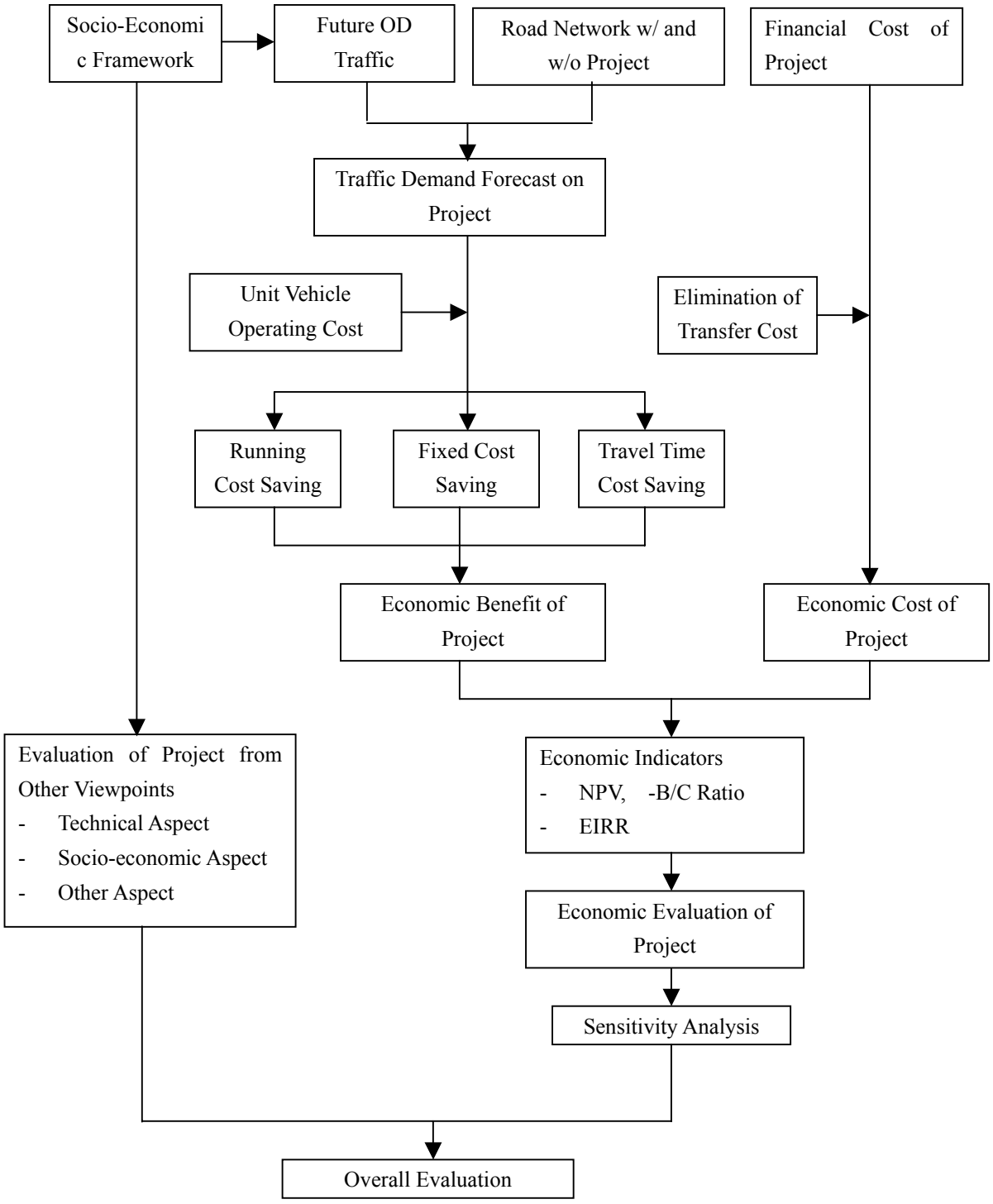


Figure 18.5-1 Procedure for Project Evaluation

Table 18.5-2 Total Vehicle Kilometers on Hamra-Rustaq Road ('000 PCU-km / Day)

		W/O Project	W/ Project	W/O-W/
2010	W/O Bridge Plan	18,168.5	17.967.1	201.3
	W/ Bridge Plan		17,959.8	208.7
2020	W/O Bridge Plan	31,719.3	31,377.6	341.7
	W/ Bridge Plan		31,363.1	356.2
2030	W/O Bridge Plan	55,377.0	54,797.5	579.5
	W/ Bridge Plan		54,769.2	607.8

Table 18.5-3 Total Vehicle Hours on Hamra-Rustaq Road (PCU-Hour / Day)

		W/O Project	W/ Project	W/O-W/
2010	W/O Bridge Plan	241,939	240,049	1,890
	W/ Bridge Plan		239,803	2,136
2020	W/O Bridge Plan	442,603	439,198	2,922
	W/ Bridge Plan		439,198	3,406
2030	W/O Bridge Plan	809,697	805,331	2,922
	W/ Bridge Plan		804,389	5,308

18.5.3 Preliminary Economic Evaluation

1) Evaluation Period

The evaluation period is assumed to be 30 years from 2010 to 2039 taking into account the service life of the Al Hamura - Rustaq Road.

2) Implementation Schedule

Following the recommended implementation schedule of the Master Plan, the implementation schedule of the Project is assumed as follows:

- 2006 Detailed design, tendering and bidding
- 2007 – '09 Construction of Al Hamura- Rustaq Road (Phase 4)

3) Plans to be evaluated

There are two (2) plans of construction of Hamra - Rustaq Road to be evaluated as follows:

- Without Bridge Plan: Constrction of Hamra – Rustaq Road without new Arch Bridge
- With Bridge Plan: Construction of Hamra – Rustaq Road with new Arch Bridge

4) Economic Indicators

The economic indicators used in this study are as follows:
– Net Present Value (NPV)
– Benefit Cost Ratio, (BCR), and
– Economic Internal Rate of Return (EIRR)

5) Estimation of Benefit

By implementing Hamra-Rustaq Road project, a variety of benefits is expected such as improvement of comfort and safety, promotion of international and inter-regional trade and promotion of regional development in long term basis. Among these benefits, limited benefits to the three (3) items of vehicle operating cost: saving in running cost (VRC) (distance related vehicle operating cost), saving in fixed cost (VFC) (time related vehicle operating cost) and travel saving in time cost (TTC).

a. Unit Vehicle Operating Cost (VOC)

Detailed unit VOC is described in Appendix A9-2. Tables 18.5-4 (1) to (3) summarizes the unit VOC on paved and unpaved surface type, VFC and TTC for vehicle groups.

Table 18.5-4 (1) Unit Running Cost by Vehicle Speed and Surface Type (RO/'000 km)

Speed (km/h)	Paved Surface			Unpaved Surface		
	Passenger Car	Bus	Truck	Passenger Car	Bus	Truck
5 km/h	66	109	116	104	177	143
30	34	43	49	53	69	61
50	33	41	47	53	66	58
70	36	44	50	57	70	62
90	41	49	55	64	79	69
110	47	57	63	73	92	78
130	54	67	73	85	108	91
150	63	79	85	99	127	105

Note: All unit costs are presented in 2005 prices

Table 18.5-4 (2) Unit Fixed Cost by Vehicle Types (RO/Hr)

Vehicle Type	Fixed Cost
Passenger Car	1.088
Bus	1.835
Truck	2.661

Note: All unit costs are presented in 2005 prices

Table 18.5-4 (3) Unit Travel Time Cost by Vehicle Types (RO/Hr)

Vehicle Type	TTC (Person Base)	TTC (Vehicle Base)
Passenger Car	0.58	1.27
Bus	0.47	5.75
Truck	0	0

Notes: 1) All unit costs are presented in 2005 prices
2) TTC means travel time cost

b. Estimation of Benefits

The saving in vehicle operating costs and travel time cost are estimated as presented shown in Table 18.5-5.

Table 18.5-5 Estimation of Benefits (RO '000 /Year)

Year		Saving in VRC	Saving in VFC	Saving in VOC	Saving in TTC	Total Saving
2010	W/O Bridge Plan	1,104.8	1,072.8	2,087.5	654.2	4,829.3
	W/ Bridge Plan	1,120.2	1,212.4	2,332.6	739.4	5,404.6
2020	W/O Bridge Plan	1,274.4	1,657.3	2,931.7	1,010.7	6,874.1
	W/ Bridge Plan	1,413.7	1,936.6	3,350.3	1,181.0	7,881.5
2030	W/O Bridge Plan	1,630.8	2,478.1	4,108.9	1,511.3	9,729.0
	W/ Bridge Plan	1,839.4	3,012.9	4,852.3	1,837.4	11,542.0

Note: VRC: Vehicle running cost, VFC: Vehicle fixed cost, VOC: Vehicle operating cost (VRC+VFC), TTC: travel time cost

6) Economic Cost

a. Construction Cost

The project cost calculated in the previous section is expressed as the financial cost. The economic cost is estimated by deducting government taxes and import duty of imported materials from financial cost as shown in Table 18.5-6/1 and 18.5-6/2 without and with bridge plan, respectively.

Table 18.5-6 (1) Economic Cost Estimation (Without Bridge Plan) (RO '000)

Description		Economic Cost	Financial Cost
1	Construction Cost	7,722.8	8,011.9
1.1	Labor Cost	292.7	292.7
1.2	Material Cost	3,683.1	3.777.5
1.3	Equipment	3,470.1	3,652.7
2	Consultancy	532.8	560.9
2.1	Detailed Design	228.3	240.4
2.2	Construction Supervision	304.5	320.5
	Total	8,255.6	8,572.8

Table 18.5-6 (2) Economic Cost Estimation (With Bridge Plan) (RO '000)

Description		Economic Cost	Financial Cost
1	Construction Cost	10,431.9	10,743.2
1.1	Labor Cost	341.5	351.6
1.2	Material Cost	5,164.3	5,318.4
1.3	Equipment	4,926.1	5,073.1
2	Consultancy	432.8	560.9
2.1	Detailed Design	306.2	322.3
2.2	Construction Supervision	408.2	429.7
	Total	11,146.0	11,495.0

b. Maintenance Cost

The maintenance cost of the Hamra Rustaq Road is estimated on the basis of maintenance costs per kilometer applied on other national roads, which is RO 361 per km.

7) Benefit Cost Analysis

The economic analysis of the Project is carried out based on the above mentioned economic benefit and cost estimations. Table 18.5-7 shows the benefit – cost analysis of the Hamra Rustaq Road Construction Project during a project life period of 30 years and Tables 18.5-8 (1) and (2) shows the benefit - cost stream.

Economic indicators show that both plans are economically feasible. However, construction of the proposed bridge gives lower indication from view points of B/C ratio and EIRR.

Table 18.5-7 Economic Indicators of Benefit Cost Analysis

	Without Bridge Plan	With Bridge Plan
Net Present Value (NPV)	RO 34.1 million	RO 37.8 million
BCR	4.95	4.24
EIRR	27.3%	23.9%

Note: 1) Project life is assumed to be 30 years
2) Discount rate is assumed to be 6%.

8) Sensitivity Analysis

The sensitivity analysis is conducted under a worse case scenario incorporating increase and/or decrease of the estimation of economic cost and benefit. Table 18.5-9 shows the results of the sensitivity analysis regarding to benefit and cost.

Table 18.5-9 Sensitivity Analysis of Hamra - Rutaq Road Construction Project regarding to Benefit and Cost

			Benefit		
			20% down	Base Case	20% up
Cost	20% down	NPV (RO Million)	27.7	33.8	41.8
		B/C Ratio	4.95	6.19	7.42
		EIRR (%)	27.2	32.0	36.4
	Base Case	NPV (RO Million)	24.1	32.1	40.2
		B/C Ratio	3.96	4.95	5.94
		EIRR (%)	23.0	27.2	31.1
	20% up	NPV (RO Million)	22.4	30.5	38.5
		B/C Ratio	3.30	4.12	4.95
		EIRR (%)	20.0	23.7	27.2

Note: Project life of the project is assumed to be 30 years

9) Summary of Economic Analysis

The implementation of both Hamra - Rustaq Road construction plans can be justified from view of national economic point of view since the economic indicators of all cases are higher than the opportunity rate of the capital investment in Oman which is designated at 6 % per annum. Regarding to the two plans, without Bridge plan is superior to with Bridge Plan. However, the second plan is expected to generate more NPV than the first plan.

Table 18.5.8 (1) Benefit - Cost Stream of Al Hamra - Rustaq Road Construction Project (Without Bridge Plan)

Undiscounted Benefit Cost Stream

RO '000

Sq	Year	Construction Cost	O & M Cost	Cost Total	Benefit	Cost-Benefit
1	2005	0.0	0.0	0.0	0.0	0.0
2	2006	228.3	0.0	228.3	0.0	-228.3
3	2007	2,809.6	0.0	2,809.6	0.0	-2,809.6
4	2008	2,809.6	0.0	2,809.6	0.0	-2,809.6
5	2009	2,408.2	0.0	2,408.2	0.0	-2,408.2
6	2010	0.0	154.5	154.5	2,741.8	2,587.3
7	2011	0.0	154.5	154.5	2,842.0	2,687.5
8	2012	0.0	154.5	154.5	2,946.1	2,791.6
9	2013	0.0	154.5	154.5	3,054.5	2,900.0
10	2014	0.0	154.5	154.5	3,167.1	3,012.6
11	2015	0.0	154.5	154.5	3,284.2	3,129.7
12	2016	0.0	154.5	154.5	3,405.9	3,251.4
13	2017	0.0	154.5	154.5	3,532.5	3,378.0
14	2018	0.0	154.5	154.5	3,664.2	3,509.7
15	2019	0.0	154.5	154.5	3,801.2	3,646.7
16	2020	0.0	154.5	154.5	3,942.4	3,787.9
17	2021	0.0	154.5	154.5	4,091.7	3,937.2
18	2022	0.0	154.5	154.5	4,245.8	4,091.3
19	2023	0.0	154.5	154.5	4,406.1	4,251.6
20	2024	0.0	154.5	154.5	4,572.9	4,418.4
21	2025	0.0	154.5	154.5	4,746.5	4,592.0
22	2026	0.0	154.5	154.5	4,927.0	4,772.5
23	2027	0.0	154.5	154.5	5,114.9	4,960.4
24	2028	0.0	154.5	154.5	5,310.4	5,155.9
25	2029	0.0	154.5	154.5	5,513.9	5,359.4
26	2030	0.0	154.5	154.5	5,620.2	5,465.7
27	2031	0.0	154.5	154.5	5,722.3	5,567.8
28	2032	0.0	154.5	154.5	5,826.4	5,671.9
29	2033	0.0	154.5	154.5	5,932.4	5,777.9
30	2034	0.0	154.5	154.5	6,040.4	5,885.9
31	2035	0.0	154.5	154.5	6,150.5	5,996.0
32	2036	0.0	154.5	154.5	6,262.7	6,108.2
33	2037	0.0	154.5	154.5	6,377.0	6,222.5
	Total	8,255.6	4,324.8	12,580.4	127,243.0	114,662.6

Discounted Benefit Cost Stream

RO '000

Sq	Year	Discounted	Construction Cost	O & M Cost	Cost Total	Benefit	Cost-Benefit
1	2005	1.000	0.0	0.0	0.0	0.0	0.0
2	2006	1.060	215.4	0.0	215.4	0.0	-215.4
3	2007	1.124	2,500.5	0.0	2,500.5	0.0	-2,500.5
4	2008	1.191	2,359.0	0.0	2,359.0	0.0	-2,359.0
5	2009	1.262	1,907.5	0.0	1,907.5	0.0	-1,907.5
6	2010	1.338	0.0	115.4	115.4	2,048.8	1,933.4
7	2011	1.419	0.0	108.9	108.9	2,003.5	1,894.6
8	2012	1.504	0.0	102.7	102.7	1,959.3	1,856.6
9	2013	1.594	0.0	96.9	96.9	1,916.4	1,819.5
10	2014	1.689	0.0	91.4	91.4	1,874.6	1,783.2
11	2015	1.791	0.0	86.2	86.2	1,833.9	1,747.7
12	2016	1.898	0.0	81.4	81.4	1,794.2	1,712.8
13	2017	2.012	0.0	76.8	76.8	1,755.5	1,678.7
14	2018	2.133	0.0	72.4	72.4	1,717.9	1,645.5
15	2019	2.261	0.0	68.3	68.3	1,681.3	1,613.0
16	2020	2.397	0.0	64.4	64.4	1,645.0	1,580.6
17	2021	2.540	0.0	60.8	60.8	1,610.7	1,549.9
18	2022	2.693	0.0	57.4	57.4	1,576.7	1,519.3
19	2023	2.854	0.0	54.1	54.1	1,543.6	1,489.5
20	2024	3.026	0.0	51.0	51.0	1,511.4	1,460.4
21	2025	3.207	0.0	48.2	48.2	1,480.0	1,431.8
22	2026	3.400	0.0	45.4	45.4	1,449.3	1,403.9
23	2027	3.604	0.0	42.9	42.9	1,419.4	1,376.5
24	2028	3.820	0.0	40.4	40.4	1,390.2	1,349.8
25	2029	4.049	0.0	38.1	38.1	1,361.8	1,323.7
26	2030	4.292	0.0	36.0	36.0	1,309.5	1,273.5
27	2031	4.549	0.0	34.0	34.0	1,257.8	1,223.8
28	2032	4.822	0.0	32.0	32.0	1,208.2	1,176.2
29	2033	5.112	0.0	30.2	30.2	1,160.6	1,130.4
30	2034	5.418	0.0	28.5	28.5	1,114.8	1,086.3
31	2035	5.743	0.0	26.9	26.9	1,070.9	1,044.0
32	2036	6.088	0.0	25.4	25.4	1,028.7	1,003.3
33	2037	6.453	0.0	23.9	23.9	988.2	964.3
		Total	6,982.4	1,640.0	8,622.4	42,712.2	34,089.8

Discount Rate	6.0%

NPV (RO Million)	**34.1**
B/C Ratio	**4.95**
EIRR	**27.3**

Cost	1
Benefit	1

Table 18.5.8 (2) Benefit - Cost Stream of Al Hamra - Rustaq Road Construction Project (With Bridge Plan)

Undiscounted Benefit Cost Stream

RO '000

Sq	Year	Construction Cost	O & M Cost	Cost Total	Benefit	Cost-Benefit
1	2005	0.0	0.0	0.0	0.0	0.0
2	2006	306.2	0.0	306.2	0.0	-306.2
3	2007	3,794.0	0.0	3,794.0	0.0	-3,794.0
4	2008	3,794.0	0.0	3,794.0	0.0	-3,794.0
5	2009	3,252.0	0.0	3,252.0	0.0	-3,252.0
6	2010	0.0	208.6	208.6	3,072.0	2,863.4
7	2011	0.0	208.6	208.6	3,191.9	2,983.2
8	2012	0.0	208.6	208.6	3,316.8	3,108.2
9	2013	0.0	208.6	208.6	3,447.1	3,238.5
10	2014	0.0	208.6	208.6	3,583.0	3,374.4
11	2015	0.0	208.6	208.6	3,724.7	3,516.1
12	2016	0.0	208.6	208.6	3,872.4	3,663.8
13	2017	0.0	208.6	208.6	4,026.5	3,817.9
14	2018	0.0	208.6	208.6	4,187.3	3,978.7
15	2019	0.0	208.6	208.6	4,355.0	4,146.4
16	2020	0.0	208.6	208.6	4,531.3	4,322.7
17	2021	0.0	208.6	208.6	4,712.5	4,503.9
18	2022	0.0	208.6	208.6	4,903.0	4,694.4
19	2023	0.0	208.6	208.6	5,101.8	4,893.2
20	2024	0.0	208.6	208.6	5,309.3	5,100.7
21	2025	0.0	208.6	208.6	5,525.7	5,317.1
22	2026	0.0	208.6	208.6	5,751.8	5,543.2
23	2027	0.0	208.6	208.6	5,987.7	5,779.1
24	2028	0.0	208.6	208.6	6,233.9	6,025.3
25	2029	0.0	208.6	208.6	6,491.0	6,282.4
26	2030	0.0	208.6	208.6	6,689.7	6,481.1
27	2031	0.0	208.6	208.6	6,823.8	6,615.2
28	2032	0.0	208.6	208.6	6,960.8	6,752.2
29	2033	0.0	208.6	208.6	7,100.6	6,892.0
30	2034	0.0	208.6	208.6	7,243.3	7,034.7
31	2035	0.0	208.6	208.6	7,389.1	7,180.5
32	2036	0.0	208.6	208.6	7,537.8	7,329.2
33	2037	0.0	208.6	208.6	7,689.7	7,481.1
	Total	11,146.3	5,841.9	16,988.2	148,759.5	131,771.3

Discounted Benefit Cost Stream

RO '000

Sq	Year	Discounted	Construction Cost	O & M Cost	Cost Total	Benefit	Cost-Benefit
1	2005	1.000	0.0	0.0	0.0	0.0	0.0
2	2006	1.060	288.9	0.0	288.9	0.0	-288.9
3	2007	1.124	3,376.7	0.0	3,376.7	0.0	-3,376.7
4	2008	1.191	3,185.6	0.0	3,185.6	0.0	-3,185.6
5	2009	1.262	2,575.9	0.0	2,575.9	0.0	-2,575.9
6	2010	1.338	0.0	155.9	155.9	2,295.6	2,139.7
7	2011	1.419	0.0	147.1	147.1	2,250.1	2,103.0
8	2012	1.504	0.0	138.8	138.8	2,205.9	2,067.1
9	2013	1.594	0.0	130.9	130.9	2,162.8	2,031.9
10	2014	1.689	0.0	123.5	123.5	2,120.8	1,997.3
11	2015	1.791	0.0	116.5	116.5	2,079.9	1,963.4
12	2016	1.898	0.0	109.9	109.9	2,039.9	1,930.0
13	2017	2.012	0.0	103.7	103.7	2,001.0	1,897.3
14	2018	2.133	0.0	97.8	97.8	1,963.2	1,865.4
15	2019	2.261	0.0	92.3	92.3	1,926.2	1,833.9
16	2020	2.397	0.0	87.1	87.1	1,890.8	1,803.7
17	2021	2.540	0.0	82.1	82.1	1,855.1	1,773.0
18	2022	2.693	0.0	77.5	77.5	1,820.8	1,743.3
19	2023	2.854	0.0	73.1	73.1	1,787.4	1,714.3
20	2024	3.026	0.0	69.0	69.0	1,754.8	1,685.8
21	2025	3.207	0.0	65.1	65.1	1,722.9	1,657.8
22	2026	3.400	0.0	61.4	61.4	1,691.9	1,630.5
23	2027	3.604	0.0	57.9	57.9	1,661.6	1,603.7
24	2028	3.820	0.0	54.6	54.6	1,632.0	1,577.4
25	2029	4.049	0.0	51.5	51.5	1,603.1	1,551.6
26	2030	4.292	0.0	48.6	48.6	1,558.7	1,510.1
27	2031	4.549	0.0	45.9	45.9	1,499.9	1,454.0
28	2032	4.822	0.0	43.3	43.3	1,443.4	1,400.1
29	2033	5.112	0.0	40.8	40.8	1,389.1	1,348.3
30	2034	5.418	0.0	38.5	38.5	1,336.8	1,298.3
31	2035	5.743	0.0	36.3	36.3	1,286.5	1,250.2
32	2036	6.088	0.0	34.3	34.3	1,238.1	1,203.8
33	2037	6.453	0.0	32.3	32.3	1,191.6	1,159.3
		Total	9,427.1	2,215.7	11,642.8	49,409.9	37,767.1

Discount Rate	6.0%

NPV (RO Million)	**37.8**
B/C Ratio	**4.24**
EIRR	**23.9**

Cost	1
Benefit	1

18.5.4 Technical Evaluation

The results of the technical analysis of the Hamra - Rustaq Road show that the Hamra - Rustaq Road construction project is technically feasible. However, the following technical notes shall be considered in the detailed design stage.

- According to the preliminary engineering design, it is inevitable to avoid the steep gradient of 12.33 % between station 0.000 and station 2.400 and of 13.53 % between station 6.500 and station 8.300. Taking into account the environmental considerations and function of this road, the preliminary design made in this study shall be accepted at this stage.
- The area that the Hamra - Rustaq Road are sometimes influenced by heavy rain. In order to minimize damage of the road, proper Irish crossing and slope protection are proposed in this Study.

18.5.5 Evaluation Form Other Aspects

1) Improvement of Standard Living of Peoples

Construction of the Project Road is expected to contribute to the improvement of standard living of peoples. At present, it is estimated that 2,464 peoples in Rustaq side and 1,467 peoples in Hamra side are living at present within the influence areas of the Project Road as shown in Table 18.5-10, which can not be accessible without four (4) wheel drive vehicles. Daily travel such as ‘to work’ trip for workers, ‘to school’ trips for school children, ‘business’ trip for business men, and ‘ private’ trip for people can not be made without four (4) wheel drive vehicles.

After completion of the Project Road, the Project will contribute to

- More opportunities to access various basic facilities, such as religious facilities, hospitals, markets,
- Achievement of easier daily travel to offices for employed people, and schools for school children,
- More chances of developing unutilized potential lands,
- Contribution to effective land use and the unity of nation

Table 18.5-10 Population, Employed Population and School Children in the Influence Area of Hamra – Rustaq Road

	2005	2010	2020	2030
Rustaq Side				
Population	2,464	2,585	2,636	2,614
No. of Employed Population	674	726	809	886
No. of School Children (below 15 ys old)	527	472	461	400
Hamra Side				
Population	1,467	1,528	1,555	1,562
No. of Employed Population	367	393	439	484
No. of School Children (below 15 ys old)	314	287	272	239

2) Regional Development

Improved road system in the project area would greatly contribute to regional development. Travel time reduction, transport cost reduction, accessibility improvement and safe, comfort and reliable means of transportation would be directly and indirectly provide positive impact on the following;

a. Agricultural industry

- Higher farm gate prices → higher income for farmers → Upgrading the living standards → Incentive for farmers to produce → Regional economic growth

b. Tourism industry

- Cheaper transport cost / Easy accessibility to Hotels / Sightseeing spots → More tourists to visit → Regional economic growth

3) Traffic Safety

The existing road is a track road and poorly equipped with traffic safety facilities such as guard rail, etc. with the completion of the Project, the traffic safety facilities will be installed and traffic safety will be greatly improved. Also, travel by non-4WD vehicles will become possible.

18.5.6 Overall Evaluation

As mentioned above, the implementation of the Hamra – Rustaq road construction project can be justified as feasible from view of economic, technical, and social impact points.

Annex 18-1

Detailed cost estimate of Hamra – Rustaq Road with the Bridge

Item No.	Description	Unit	Unit Price (RO)	Quantity	Cost (RO)	Cost Component					
						Lab.	Mat.	Equip.	For.	Local	Tax
	Earthworks										
203	**Earthworks Excavation**										
203.1	Suitable excavation to embankment	Cu. m.	1.944	216,739	421,338	7,101	19,556	394,680	224,058	186,077	11,203
203.2	Suitable excavation to waste	Cu. m.	1.733	153,446	265,966	4,624	10,661	250,681	141,220	117,684	7,061
203.4	Borrow excavation to embankment	Cu. m.	3.660	39,033	142,859	611	48,851	93,397	50,735	89,588	2,537
206	**Excavation and Backfilling for Structures**										
206.1	Structural excavation in soils to a depth of 2m.	Cu. m.	1.459	26,431	38,551	1,049	2,177	35,326	19,878	17,679	994
206.3	Structural excavation in rock to a depth of 2m.	Cu. m.	2.625	27,743	72,834	1,335	2,923	68,575	38,622	32,281	1,931
206.4	Structural excavation in rock to a depth more than 2m.	Cu. m.	3.990	21,270	84,867	2,545	16,659	65,663	39,298	43,605	1,965
	Subbase and Base course										
302	**Granular Subbase**										
302.1	Class A Subbase	Cu. m.	5.000	0	0	0	0	0	0	0	0
302.2	Class B Subbase	Cu. m.	4.000	55,177	220,707	4,534	48,991	167,183	92,426	123,661	4,621
302.3	Class C Subbase	Cu. m.	3.000	0	0	0	0	0	0	0	0
303	**Aggregate Basecourse**				0						
303.1	Class A Basecourse	Cu. m.	5.000	0	0	0	0	0	0	0	0
303.2	Class B Basecourse	Cu. m.	4.000	41,566	166,265	3,476	35,920	126,869	70,221	92,533	3,511
303.3	Class C Basecourse	Cu. m.	3.000	0	0	0	0	0	0	0	0
	Bituminous Pavement										
401	**Bituminous Prime Coat and Tack Coat**										
401.1	Prime Coat such as MC70	Kg	0.120	257,500	30,900	90	30,535	275	19,981	9,920	999
401.2	Tack Coat such as RC250	Kg	0.150	0	0	0	0	0	0	0	0
405	**Bituminous Wearing Course**										
405.1	Bituminous Wearing Course	Cu. m.	17.000	28,178	479,019	1,186	447,892	29,941	306,932	156,740	15,347
	Concrete and Concrete Structures										
504	**Concrete for Structures**										
504.1	Concrete Class 28/20	Cu. m.	40.000	24,629	985,175	77,443	494,830	412,901	343,674	624,317	17,184
504.2	Concrete Class 32/20	Cu. m.	45.000	0	0	0	0	0	0	0	0
504.3	Concrete Class 36/20	Cu. m.	50.000	0	0	0	0	0	0	0	0
509	**Reinforcing Steel**										
509.1	High yield steel bars	ton	250.000	1,199	299,787	11,786	261,858	26,142	183,983	106,605	9,199
509.2	Mild steel bars	ton	250.000	33	8,285	359	7,179	746	5,060	2,972	253
	Drainage										
801	**Pipe Culverts**										
801.1	Reinforced Concrete Pipe Culvert 600 mm	Lin. m.	35.000	14	490	18	113	359	256	221	13
801.2	Reinforced Concrete Pipe Culvert 750 mm	Lin. m.	50.000	0	0	0	0	0	0	0	0
801.3	Reinforced Concrete Pipe Culvert 900 mm	Lin. m.	75.000	14	1,050	38	243	770	548	474	27
801.4	Reinforced Concrete Pipe Culvert 1050 mm	Lin. m.	100.000	0	0	0	0	0	0	0	0
801.5	Reinforced Concrete Pipe Culvert 1500 mm	Lin. m.	155.000	252	39,060	1,406	9,023	28,631	20,389	17,651	1,019
	Slope Protection										
901	**Rip Rap**										
901.1	Loose stone riprap Class A	Cu. m.	6.000	10,652	63,911	1,770	15,360	46,781	26,381	36,210	1,319
901.2	Loose stone riprap Class B	Cu. m.	6.000	0	0	0	0	0	0	0	0
901.3	Mortared stone riprap	Cu. m.	15.000	37,317	559,750	34,301	306,569	218,881	165,619	385,850	8,281
902	**Gabions**				0						
902.1	Gabions	Cu. m.	13.000	0	0	0	0	0	0	0	0
906	**Ditch lining**				0						
906.1	Ditch lining (150mm thick)	Sq. m.	2.000	26,819	53,638	6,479	25,875	21,285	15,360	37,511	768
	Bridge (Arch Bridge L=190m, W=14m)				3,300,000	118,800	1,689,600	1,491,600	2,006,400	1,193,280	100,320
	MSCELLANEOUS STRUCTURES(1300 SAFETY BARRIERS, DELINEATORS AND FENCES, 1400 HIGHWAY SIGNS AND ROAD MARKINGS, AND OTHER ITEMS, 10% of SECTION 200 to SECTION				723,445	30,205	555,519	137,720	522,323	175,005	26,116
	MEASURED WORKS TOTAL (SECTION 200 to 1900)				7,957,897	309,155	4,030,334	3,618,408	4,293,362	3,449,866	214,668
	SECTION 100 PRELIMINARIES (25% of SECTION 200 to SECTION 1800)		------		1,989,474	16,439	894,088	1,078,947	1,471,594	444,300	73,580
	SUB TOTAL				9,947,371	325,593	4,924,422	4,697,355	5,764,956	3,894,166	288,248
	CONTINGENCY (10% of SECTION 200 to SECTION 1800)		------		795,790						
	Total				10,743,160						

Annex 18-2

Detailed cost estimate of Hamra – Rustaq Road without the Bridge

Item No.	Description	Unit	Unit Price (RO)	Quantity	Cost (RO)	Cost Component					
						Lab.	Mat.	Equip.	For.	Local	Tax
	Earthworks										
203	**Earthworks Excavation**										
203.1	Suitable excavation to embankment	Cu. m.	2.109	267,489	564,189	9,715	26,329	528,145	300,204	248,975	15,010
203.2	Suitable excavation to waste	Cu. m.	1.731	160,743	278,299	4,827	11,130	262,342	147,759	123,152	7,388
203.4	Borrow excavation to embankment	Cu. m.	3.660	71,379	261,246	1,117	89,333	170,795	92,778	163,829	4,639
206	**Excavation and Backfilling for Structures**										
206.1	Structural excavation in soils to a depth of 2m.	Cu. m.	1.475	27,523	40,597	1,121	2,418	37,058	20,860	18,694	1,043
206.3	Structural excavation in rock to a depth of 2m.	Cu. m.	2.625	27,743	72,834	1,335	2,923	68,575	38,622	32,281	1,931
206.4	Structural excavation in rock to a depth more than 2m.	Cu. m.	4.043	30,963	125,192	3,626	26,174	95,393	57,441	64,879	2,872
	Subbase and Base course										
302	**Granular Subbase**										
302.1	Class A Subbase	Cu. m.	5.000	0	0	0	0	0	0	0	0
302.2	Class B Subbase	Cu. m.	4.000	60,639	242,558	4,982	53,841	183,734	101,576	135,903	5,079
302.3	Class C Subbase	Cu. m.	3.000	0	0	0	0	0	0	0	0
303	**Aggregate Basecourse**				0						
303.1	Class A Basecourse	Cu. m.	5.000	0	0	0	0	0	0	0	0
303.2	Class B Basecourse	Cu. m.	4.000	45,461	181,843	3,801	39,285	138,756	76,800	101,203	3,840
303.3	Class C Basecourse	Cu. m.	3.000	0	0	0	0	0	0	0	0
	Bituminous Pavement										
401	**Bituminous Prime Coat and Tack Coat**										
401.1	Prime Coat such as MC70	Kg	0.120	283,000	33,960	98	33,559	303	21,960	10,902	1,098
401.2	Tack Coat such as RC250	Kg	0.150	0	0	0	0	0	0	0	0
405	**Bituminous Wearing Course**										
405.1	Bituminous Wearing Course	Cu. m.	17.000	30,754	522,811	1,295	488,839	32,678	334,992	171,070	16,750
	Concrete and Concrete Structures										
504	**Concrete for Structures**										
504.1	Concrete Class 28/20	Cu. m.	40.000	40,943	1,637,731	128,740	822,594	686,398	571,315	1,037,851	28,566
504.2	Concrete Class 32/20	Cu. m.	45.000	0	0	0	0	0	0	0	0
504.3	Concrete Class 36/20	Cu. m.	50.000	0	0	0	0	0	0	0	0
509	**Reinforcing Steel**										
509.1	High yield steel bars	ton	250.000	2,077	519,281	20,416	453,582	45,283	318,688	184,658	15,934
509.2	Mild steel bars	ton	250.000	33	8,285	359	7,179	746	5,060	2,972	253
	Drainage										
801	**Pipe Culverts**										
801.1	Reinforced Concrete Pipe Culvert 600 mm	Lin. m.	35.000	14	490	18	113	359	256	221	13
801.2	Reinforced Concrete Pipe Culvert 750 mm	Lin. m.	50.000	0	0	0	0	0	0	0	0
801.3	Reinforced Concrete Pipe Culvert 900 mm	Lin. m.	75.000	98	7,350	265	1,698	5,388	3,837	3,321	192
801.4	Reinforced Concrete Pipe Culvert 1050 mm	Lin. m.	100.000	0	0	0	0	0	0	0	0
801.5	Reinforced Concrete Pipe Culvert 1500 mm	Lin. m.	155.000	252	39,060	1,406	9,023	28,631	20,389	17,651	1,019
	Slope Protection										
901	**Rip Rap**										
901.1	Loose stone riprap Class A	Cu. m.	6.000	10,652	63,911	1,770	15,360	46,781	26,381	36,210	1,319
901.2	Loose stone riprap Class B	Cu. m.	6.000	0	0	0	0	0	0	0	0
901.3	Mortared stone riprap	Cu. m.	15.000	41,701	625,516	38,331	342,588	244,597	185,078	431,184	9,254
902	**Gabions**										
902.1	Gabions	Cu. m.	13.000	0	0	0	0	0	0	0	0
906	**Ditch lining**										
906.1	Ditch lining (150mm thick)	Sq. m.	2.000	35,999	71,998	8,697	34,731	28,570	20,617	50,350	1,031
	MSCELLANEOUS STRUCTURES(1300 SAFETY BARRIERS, DELINEATORS AND FENCES, 1400 HIGHWAY SIGNS AND ROAD MARKINGS, AND OTHER ITEMS, 10% of SECTION 200 to SECTION				529,715	22,116	406,758	100,841	382,451	128,141	19,123
	MEASURED WORKS TOTAL (SECTION 200 to 1900)				5,826,866	254,035	2,867,457	2,705,374	2,727,066	2,963,447	136,353
	SECTION 100 PRELIMINARIES (25% of SECTION 200 to SECTION 1800)		------		1,456,717	12,037	654,662	790,018	1,077,519	325,322	53,876
	SUB TOTAL				7,283,583	266,071	3,522,119	3,495,392	3,804,584	3,288,769	190,229
	CONTINGENCY (10% of SECTION 200 to SECTION 1800)		------		582,687						
	Total				7,866,270						

Annex 18-3

ENVIRONMENTAL CHECKLIST (HAMRA TO RUSTAQ ROAD)

Road Section: From Hamra to Rustaq, Existing road condition: Gravel road

Project Road No.: N27, Planning road: Metalled 2-lane road, Distance: 28.3km

Environmental Items	Present environmental condition	Impact Rating 1 = Slight 2 = Moderate 3= Significant	Remarks Predicted traffic volume in 2030: 10,000 veh/day
Air Pollution	- Not significant so far, because very low traffic volume.	1~2	- Although the project area at present is low population, slight to moderate impact to air quality is anticipated due to increase of future traffic volume, approximately 10,000 veh/day, and narrow wadi channels around Zammah and Far villages.
Effluent and Water contamination	- Not significant so far.	1	- Additional impact to effluent and water quality due to new road construction is not anticipated in the area.
Noise and Vibration	- Not significant so far.	1~2	- Although the project area in very low population, slight to moderate impact to noise pollution is anticipated due to increase of future traffic volume, approximately 10,000 veh/day, and narrow wadi channels around Zammah and Far villages.

Land Subsidence	- No existing in the area.	1	- Not existing.
Topography and Geology  Photo: Gentle slope in south part of Al Jabal Al Akdar Mountains  Photo: Steep slope in north part of Al Jabal Al Akdar Mountains	Topography: - Project area is located in the central part of the Al Hajar Al Gharbi Mountains. Al Jabal Al Akdar (Jabal Shams) Mountains, being the highest peak, 3,009m above sea level, in Oman, is located 10km west of the area and mountain ridge from Jabal Shams is connected to the project area. - Southern slope of the Al Jabal Al Akdar mountain ridge is characterized by large scale of cuesta topography showing gentle slope. On the contrary, northern slope of the Al Jabal Al Akdar mountain ridge is characterized by steep slope to vertical cliff as the cuesta topography. The project road section belongs to the northern steep slope area. (1) 0 (Start point: Hat village)~15.3km (Junction to Fashah): - The road section between them, marked by rugged and steep slope topography, belongs to the high to moderate relief of mountain and passes along Wadi al Hatt and Wadi Bani Awf. V-shape deeply incised valleys and likely oddly shape rock outcroppings show in many places.	1~2	- Slight to moderate impact due to road construction in the central part of Al Hajar Mountains with relatively thick wadi vegetation. It is necessary to follow the existing road alignment for minimizing of cutting.  Photo: Deeply incised valley  Photo: V-shape deep valley at Zammmah

	(2) 15.3~28.3km (End point): This road section is also marked by rugged mountainous terrain and belongs to the moderate and low relief of mountain. The section passes along wadi channel of Wadi Bani Awf. Near end point of the road changes lower hills and to flatter terrain. Geology: - The project area crossing the Al Jabal Al Akdar Mountains are continuously cropped out the Autochthonous Units, consisting of the Huqf Group of End-Protoezoic to Cambrian age and Akhdar Group, Sahtan Group, Kahmah Group and Wasia Group ranging in age from Late Permian to Middle Cretaceous. The Huqf Group is intensely metamorphosed and shows fine schistose. - The geological structure clearly shows anticline deformation (dome structure) in large scale. - Igneous rocks originated from ancient ocean floor, so-called Samail Ophiolite, are locally found near end point of the project road.		 Photo: Cutting of Existing road  Photo: Limestone of Deformed Huqf Group
Soil	- Soil is poorly developed, mostly suffered by wind erosion. Alluvial soil is found in the wadi and terraces, but mostly thin.	1~2	- Slight to moderate impact to surface soil due to road construction. It is necessary to follow the existing road alignment for minimizing of cutting.

Hydrology, groundwater  Photo: Falaj at downstream of Al Bir  Photo: Wadi sediments in Aadi Bani Awf	Hydrology: - Precipitation in the project area is relatively high, 200 to 300mm by year. These events can produce rapid runoff and major wadi underflow. - Although the road section from 0 km to 7.8km passes the steep slope, rest of road section from 7.8 km to 28.3 km (End point) mostly passes in the wadi channels of Wadi Bani Awf, which are likely to experience flooding. Groundwater: - There are eight settlements in the project area. Most of settlements get water by falaj system. At present, no falaj system crosses existing road.	1	- Not significant impact with project. However, as the project area has relatively much precipitation, it is necessary to install enough drainage system and protection against flooding flows.  Photo: Water gage in Wadi Bani Awf

Eco-system, Flora and Fauna  Photo: Wadi vegetation in Wadi al Hat  Photo: Wadi vegetation in Wadi Bani Awf	Flora: - Vegetation is found along the entire stretch of the project area. The lower lying hills have less vegetative cover than the higher areas, except for depressions and wadi flow channels. The vegetation can be classified as an open xenomorphic *Euphorbia* community type. Much of this area represents a good example of undisturbed habitat in northern Oman. Fauna: - Wildlife known to the area includes the Arabian Leopard, Gazelle, Arabian tahr and other fauna such as the red fox, etc. The IUCN red list of threatened animals (IUCN 1990) describes the mountain gazelle as vulnerable. Leopard and the tahr are considered endangered.	2	- Whilst the area does not have official reserve status, permits are required to enter some areas. - This area could be one of the protection areas proclaimed as Nature Reserve in near future. - Any development in the area will be considered as having a significant impact as a result of the valuable nature of the habitat, because of rapidly increase of traffic volume in future. The future traffic volume in 2030 is predicted to be 10,000 veh/day in the project area. - It is necessary to investigate concerning eco-system, flora and fauna in the area, particularly relationship between the Al Jabal Al Akdar area and project area before construction or during EIA.
Landscape	- The area is the most typical landscape of highland in Oman.	1	- Minimum cut and embankment will be required for the road construction.
Hazards	- Not existing so far. But small erosion of road due to flooding is found in some places.	1	- Not existing impact by road improvement.
Regional Development on Natural Environment	- Not existing so far.	1	- Unknown.
Other Impacts on Natural Environmenta1	- Not existing so far.	1	- Unknown.
Cultural Heritage	- Not existing so far.	1~2	- The investigation of the cultural heritage in the

			site might be required before road construction.
Wastes	- Not significant so far.	1	- As high future traffic volume in 2030 is predicted, wastes along the road and parking areas could be increased. And increase of uncontrolled wastes might be affected to the eco-system.
Regional Development on Social Environment	- Not existing so far.	1	- Unknown.

Other Impacts on Social Environment  Photo: Hat village  Photo: Small settlement in Wadi Hat  Photo: Narrow wadi channel	- 0 km: Junction to Hat village. The distance between junction and Hat village is about 1km. - 1.5 km: 6 houses and Date farm with falaj system. Unknown name of this small settlement. The settlement is located 40m from existing road. There is water flow in Wadi Hat. Electricity is supplied. 3.7km: Deep and narrow valley, bridge is planned to build, 12o long, as a alternative. - 5.1km: Bimah settlement. 2 houses and date farms with falaj system. The settlement is located 400m from existing road. - 5.1km: Zammah village. 12 houses and date farms with falaj system. The village is located on the lowermost terrace and existing road passes in the wadi. No school in village. - 13.4km: 3 houses and small farm. The settlement is located in narrow wadi channel and 50m away from existing road. Electricity is supplied. - 15.3km: Junction to Fashah. Road passes in the wider wadi, ranging in width from 40m to 200m. - 18.3km: Teekah: 10 houses, date farm and Medical office. - 20.0 km: Water flow gage and falaj. - 20.4km: Al Wasit, 1 house and small date farm. and long date farms. Rich vegetation. - 26.8km: Water gage of MRMEWR. - 28.3km: Junction of NR No.13 to Ar Rustaq. Substation.	1~2	- Some sections of the road pass through and nearby or inside of the villages and areas of farmland, which may be impacted by the road development. Because high traffic volume, approximately 10,000 veh/day in 2030, is predicted. Particularly, narrow wadi channels around Zammah and Far villages. - Increased chance of traffic accident as well as domestic animals due to increased traffic volume.  Photo: Narrow wadi channel near Far village

	- 23.9 km: 2 houses and small date farm. - 25.6~26.1km: Far village. More than 50 houses		

Evaluation	**- Air quality**	**1~2**	**Increased traffic volume**
	- Noise	**1~2**	**Increased traffic volume**
	- Topography and Geology	**1~2**	**Alteration of topography**
	- Soil	**1~2**	**Alteration of topography**
	- Eco-system, Flora and Fauna	**2**	**High potential of various species of flora and fauna** **Increase of wastes due to increase of visitors** **Increased traffic volume**
	- Cultural heritage	**1~2**	**Influence to cultural heritage**
	- Other Impacts on Social Environment	**1~2**	**Increase of chance of traffic accidents due to increased traffic volume**
	- Other items	**1**	

Comprehensive Evaluation	**2**
Recommendations *1	**Recommended to carry out EIA**

***1 : Comprehensive Evaluation**

1	**: None to slight impacts.**	**: No need to carry out EIA**
1~2	**: Small impacts.**	**: Recommended to carry out EIA on assigned items**
2	**: Moderate impacts.**	**: Recommended to carry out EIA**
2~3	**: Relatively significant impacts.**	**: Recommended to carry out EIA**
3	**: Significant impacts.**	**: Recommended to carry out EIA**

Annex 18-4

TERMS OF REFERENCE
ON
THE ENVIRONMENTAL IMPCT ASSESSMENT
OF
THE HAMRA - RUSTAQ RORD,

SULTANATE OF OMAN

1. Project Title

"Environmental Impact Assessment of the Hamrat – Rustaq Road, Sultanate of Oman" (hereinafter referred to as "Study")

2. Executive Agency

Directorate General of Road, (hereinafter referred to as "DGR"), Ministry of Transport and Communications, Sultanate of Oman.

3. Location of Project Area

Project area is located in the central part of the Al Hajar Al Gharbi Mountains. Jabal Shams Mountain, being the highest peak in Oman, 3,009m above sea level, is located 10km west of start point of the project road, and mountain ridge from Jabal Shams is connected to the project area, as shown in Attachment-1.

4. Background of the project

The Hamrat – Rustaq Road is designated as one of the 6th (2000-2005) and 7th Plan (2006-2010) proposed projects. This road has an important role of directly connecting between Al Batinah Region and A'Dakhuliyah Region crossing the Al Hajar Al Gharbi Mountains.

The road construction between Hamrat and Rustaq, which distance of the road is 76 km, is scheduled as four sections, i.e. Road Section I, II, III, and IV. The project road is the Road Section IV.

The Road Section I was completed. Road Section II is under construction. Road Section III will be commenced to construct in this year. The road planning and design for the Road Section IV is going on.

5. Objectives of the Study

The Study should carry out to accord the Royal Decree No. 10/82 and its amendments entitled "Law on Conservation of the Environment and Prevention of Pollution" as well as other relevant regulations, decisions and guidelines.

The principles of the Study are as follows:

- EIA is a process to help decision makers to protect, conserve and manage Oman's environment, according to the principles of sustainable development, maintaining human well-being, healthy environment and a sound economy;
- The EIA process should ensure that the individual, company or government agency, proposing a project considers its effect on health, economy and culture of surrounding community as well as its impact on air, land and water;
- The EIA should be applied as early as possible in project's planning stage and before irrevocable decisions are made; and
- Public information is an important component of an open and balanced EIA process.

And, the specified objectives of the Study are shown as below:

i) To identify, predict, and assess environmental impacts due to proposed activities on the physical, biological and social environment;
ii) To propose mitigation measures for avoiding and reducing the impacts and evaluating associated risk; and
iii) To submit the Environmental Impact Assessment report and relevant documents.

6. Project Description:

The project description of the Hamrat - Rustaq Road is shown hereafter:

- The project road is located in the southeastern part of the Al Batinah Region and adjoined to the A'Dakhuliyah Region. The project road area is topographically characterized by steep northern slope of cuesta topography developed at Jabal Shams Mountain,
- The project road has important role of directly connecting between Al Batinah

Region and A'Dakhuliyah Region,
- The project road is the final road section (Section IV) of the Hamrat – Rustaq Road.
- The length of the project road is 28.3 km,
- At 3.7 km from start point it is planned to build bridge, 120 m long, as an alternative crossing deep valley,
- The road hierarchy of the project road is designated secondary road that its right-of-way is 50 m, and
- The project road traverses mostly mountainous terrains and along the wadis, as shown in Atachment-2.

7. Scope of the Study:

This project is classified as Roads of the Group five (Service projects) in accordance of the "Guidelines for Obtaining Environmental Permits" (Directorate General of Environmental Affaires). In addition, as results of the environmental consideration of the project is recommended that the project EIA should be carried out before project implementation, comprehensive EIA should be required.

In order to achieve the objectives mentioned above, the scope of the Study consist of the following items:

1) Collect and review the existing data and information relevant to the project

- Legislative information,
- Topographical, geological and pedological data,
- Aero photographs and/or satellite images covered in and around the project area,
- Meteorological data around the project,
- Hydrological and hydro-geological data relevant to the project,
- Biological and ecological data and information,
- Information of land use and its history,
- Natural scenic spots, national park, etc.,
- Information of open-air recreation,
- Information of natural hazards,
- Sociological data and information,
- Administrative data and information,
- Socio-economic data,
- Cultural and historical heritages,
- Traffic volume data, and
- Other data and information relevant to the traffic, etc.

2) Project description

- Location,
- Road design and design criteria,
- Road capacity,
- Road section for construction,
- Pre-construction activities,
- Construction plans and scheduling,
- Staffing and support,
- Associating facilities and services,
- Operating procedures and maintenances,
- Future traffic volume,
- Land use requirement, and
- Alternative alignments, etc.

3) Site description and its environment (Baseline survey)

The content of the baseline study consists of the following environmental items:

(1) Air quality: Measuring points consist of each villages and settlements as well as start and end points, and number of measuring times is two, i.e. summer and winter seasons, and measuring parameters consist of SO_2, TSP, PM_{10} and fallen-dust,
(2) Water quality: measuring points consist of each surface water flows, wells, water spring, and aflaj water, and number of measuring times is two, i.e. summer and winter seasons, and analysis parameters consist of pH, Electric conductivity (EC), Water temperature, Ca, Mg, Fe, Mn, K, Na, CO_3, Hg, Pb, As, Cr, Cd, Se, SO_4 and Cl,
(3) Noise and vibration: measuring points consists of each villages and settlements, and number of measuring times is two, i.e. summer and winter seasons, and measuring parameter is dB(A) on the boundary of ROW,
(4) Topography and geology: Topographical and geological investigation, and drilling survey at bridge building site, 2 holes x 10m in depth,
(5) Soil: Pedological investigation consists of soil sections at the point of every 2 km interval and each villages and farmlands,
(6) Surface water and groundwater: Hydrological and hydro-geological investigation consist of outflow and measurement in the sites, comprising of pH, EC and Water temperature,
(7) Ecosystem, flora and fauna: Number of investigating times is two, i.e. summer and winter seasons,
(8) Landscape,

(9) Hazards,
(10) Communities,
(11) Wastes,
(12) Cultural heritage,
(13) Resettlement, and
(14) Traffic volume and traffic accidents: Traffic census and interviews.

While baseline survey, the proponent should be found stakeholders, related to the project, e.g. residents of local communities in the site, indigenous people, experts from government organizations, local government officer, NGO, etc., and should be collected their opinions in order to get an appropriate agreement and to reflect to the decision-making of the project.

4) Evaluation of project's impacts

The content of the evaluation of impacts with the project consists of the following items:

- Cumulative and indirect environmental impacts, likely to result from the project in combination with existing or planned projects or activities,
- Impact on socio-economic conditions,
- Impact on physical and cultural heritage, and
- Proposal and evaluation of reasonable alternatives to the project and their impacts.

The evaluation should be carried out to use the environmental standards or guidelines to establish significant of the harmful impacts. A risk assessment can be used when there are no applicable threshold standards or guidelines. The following criteria should be applied to determine significant or adverse impacts:

(1) Magnitude,
(2) Frequency and duration,
(3) Location and sensitivity of environment, and
(4) Irreversibility.

5) Mitigating measures and evaluating associated risks

The following approaches can be used to mitigate likely significant harmful impacts:

- Direct prevention by avoiding sensitive areas,
- Reduction by adjusting work schedules, pollution control devices, changes in design, etc.,

- Restoration and remediation measures, and
- Compensation.

6) Final assessment

The final assessment should be done to evaluate through a net effect analysis.

7) Documentation

Documentation I composed of reference and working documents. The former will contain a detailed record of the work done on the EIA. The latter is the document, which contain the information for action, e.g. the Environmental Impact Statement as well as Summary.

The content of the Environmental Impact Statement should be contained the following items:

- Information describing the EIA,
- Information describing the project,
- Information describing the site and its environment, shown as below:
    (1) Physical features
    (2) Legislative framework
    (3) Assessment of impacts, shown as below:
        a. Impacts on human beings, buildings and man made features,
        b. Impacts on flora, fauna and geology,
        c. Impacts on land,
        d. Impacts on water,
        e. Impacts on air and climate,
        f. Other direct and secondary effects associated with the project,
        g. Environmental management plan – Mitigating measures and risk assessment, and
        h. Conclusions and additional information.

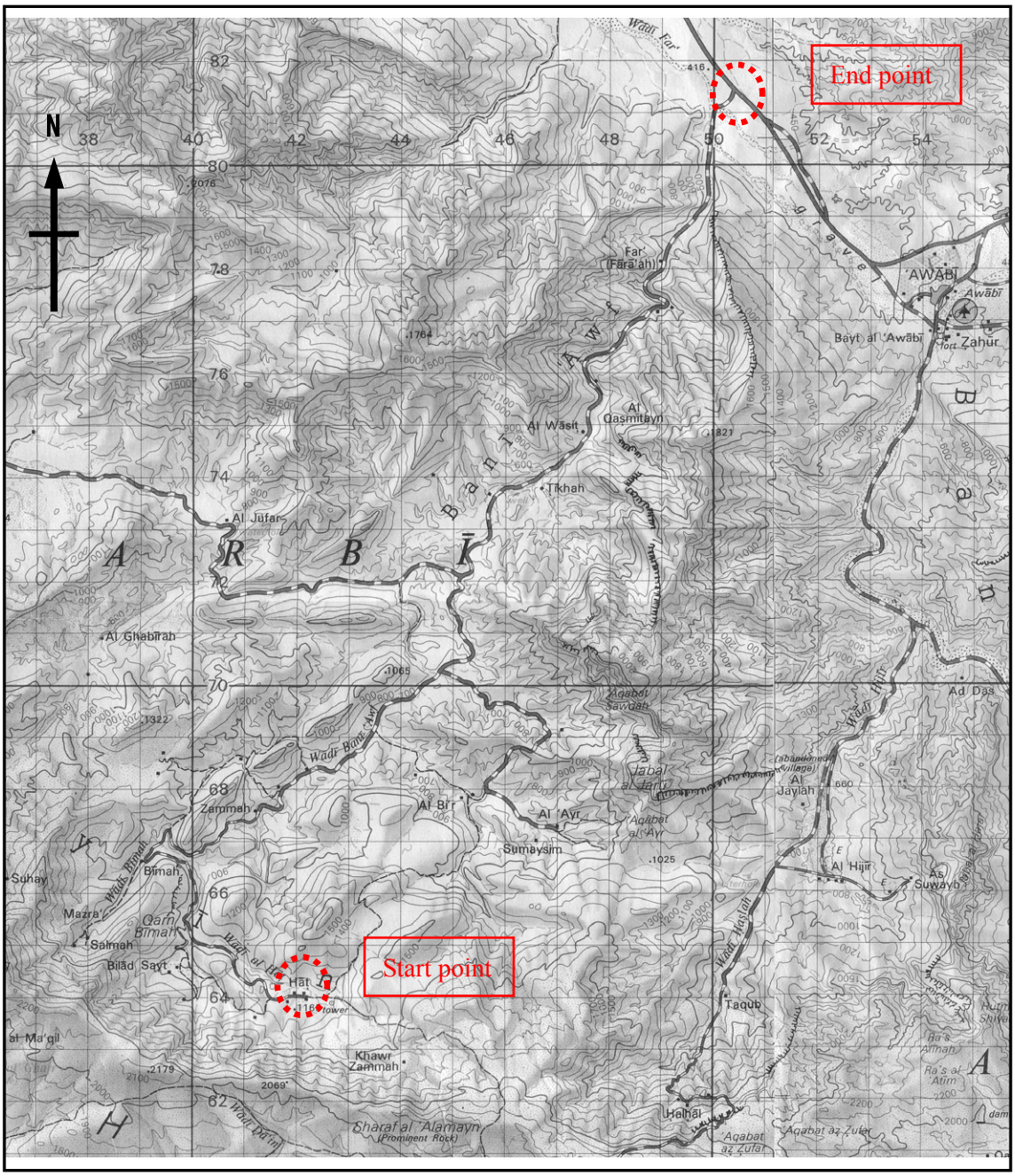
8. Study Timetable

Tentative study timetable of the project shows in Attachment-3.

Attachment:

Attachment-1 Location Map of the Project Road
Attachment-2 Topographic Map of the Project Road
Attachment-3 Tentative Study Timetable of the Project

Attachment-1 Location Map of the Project Road



Attachment-2 Topographic Map of the Project Area

Attachment-3 Tentative Study Timetable of the Project

Year	200 -															Remarks
Number of month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**-**	
1. Data collection	▬															
2. 1st. Field investigation		▬	▬	▬												Summer/winter season
3. 2nd. Field investigation								▬	▬	▬						Winter/summer season
4. Data analysis			▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪			▪▪▪	▪▪▪	▪▪▪	▪▪▪			
5. Reporting	1 △	○	○	○	○	○	○	○	○	○	○	○	○	2 △	3 △	

△ 1 : Inception report
2 : Draft Final report
3 : Final report
○ : Monthly report

▬ : Work in the site
▪▪▪ : Chemical analysis